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GEOLOGICAL SURVEY OF CANADA.

SIR W. E. LOGAN, F. R. S., DIRECTOR.

FIGURES AND DESCRIPTIONS

OF

CANADIAN ORGANIC REMAINS.

DECADE IV.

Montreal:
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NOTICE.

The plates of the present Decade were all drawn on stone by Mr. H. Smith, at the office of the Survey, and printed by Mr. Mathews, the well known lithographer of Montreal. The Decade, like those which have preceded it, will be placed in the hands of respectable booksellers for sale at a moderate price; and, judging from the demand for the first one issued, there is good reason to believe that the whole edition of two thousand copies will be ultimately disposed of, and that the work will repay the expenses of publication.

W. E. LOGAN.

Montreal, 1st May, 1859.

PREFACE.

The following Decade contains descriptions of all the Crinoids of the Lower Silurian rocks of Canada, of which specimens have been procured in such a state of preservation as to admit of their being characterized. Of these, five belong to the Chazy limestone, and the remainder to the Birdseye, Black River, Trenton, and Hudson River formations. Altogether we have about fifty species, including several which have been as yet recognized by their columns only.

Of the thirteen genera to which I have referred these species two, *Rhodocrinus* (Miller,) and *Glyptocrinus* (Hall), occur in the Silurian rocks of Europe, but none of the species are common to both sides of the Atlantic. Five of the genera, *Heterocrinus*, *Glyptocrinus*, *Dendrocrinus*, *Lecanocrinus*, and *Rhodocrinus*, have been found in the State of New York, the first two in the Lower Silurian and the last three in the Upper Silurian. None of the other eight genera have been noticed as occurring out of Canada, although it is highly probable that some, if not all of them, will, in course of time, be discovered in the Silurian rocks of the adjacent countries.

The most remarkable species is the one to which we have given the name of *Blastoidocrinus carchariædens*. This fossil, by the structure of its ventral surface, is closely allied to *Pentremites*, the typical genus of the order Blastoideæ, while the arrangement of the plates in the walls of the lower part of the body, so far as it can be made out from the imperfect specimens that have been collected, seems to connect it with the Crinoideæ. The species is interesting, as it shews us that the organization peculiar to the Blastoideæ,

heretofore not known in rocks of a more ancient date than those of the higher portions of Upper Silurian, made its appearance or existed in the Lower Silurian period.

In order to render the work more useful to the student I have given an introductory section, containing a short account of the history and structure of the Crinoideæ.

E. BILLINGS.

CANADIAN ORGANIC REMAINS.

On the CRINOIDEÆ *of the Lower Silurian Rocks of Canada.* By E. BILLINGS, F. G. S.

SECTION I.

HISTORY AND STRUCTURE OF THE CRINOIDEÆ.

AMONG the various animal forms that lie entombed in the fossiliferous portion of the earth's crust, none have attracted a greater amount of attention than the Lily Encrinites, or Crinoids,—that group of organic remains to which the following memoir is devoted. Their great abundance in many of the geological formations, the remarkable shapes of the separated fragments of the skeleton, and the peculiar flower-like form of the perfect specimens, must have in all ages excited the curiosity of those whose tastes led them to take an interest in the varied objects of nature; yet it is only within the last century and a half that the first correct ideas concerning their characters began to dawn upon the human understanding. Dr. Mantel informs us that the circular perforated joints of the column occur in the tumuli of the ancient Britons, under such circumstances as to render it quite certain that our forefathers used them for ornamental purposes, and perhaps as objects of veneration in some way connected with the rites of the druidic religion. We have no reason however to believe that they were at that time supposed to be of animal origin. In more recent times they were called, by the peasantry, "fairy-stones," "St. Cuthbert's beads," "screw-stones," or "pulley-stones"; and in Germany, "*Rosenkranzsteine*," rosary-beads;" "*Hunnenthraenen*," giant's tears; or "*Raedersteine*," wheel-stones;—some of these names having been suggested by their form and others originating in the superstitions of earlier ages.

It appears that the earliest publication in which has been found any allusion to the Crinoideæ is a book written in 1558 by Agricola,

the ingenious German miner who taught that petrifactions were not the remains of things which once had an actual existence as living creatures, but simply the shapes of animals generated in the solid rock by some material principle rendered active by the subterranean heat. Entertaining such views, he could not be expected to contribute any important assistance in determining the true characters of fossils which bore no resemblance to any animal then known. From several passages which occur in the writings of this author it seems that, previously to his time, naturalists had given to the different parts of the skeletons of the Crinoids, such as the joints of the stalk or the flower-shaped body, the names of "*Trochites*," "*Entrochus*," and "*Encrinus*," the latter giving origin to the term "Encrinite," afterwards used as a general designation for the whole order. Agricola bestowed the name of *Pentacrinus* upon the bodies of that species now so well known as *Encrinus moniliformis*, applying it not to the whole of the cup, but to specimens which had lost the arms. The separated joints of the pentagonal column, which are somewhat like a five-rayed star, he called *Astroites* or *Asteria*. It is scarcely necessary to add that he did not believe them to be animal remains.

Soon after the time of Agricola the nature of crinoidal remains became a subject of much discussion, and exercised greatly the speculative faculties of a host of writers who were more or less interested in settling the grand problem,— whether or not fossils were of animal origin. For nearly two centuries many of those who placed any confidence whatever in the affirmative of the question still regarded the Crinoids as fossil plants, and contended that the body with its branching arms was the root; others thought that the jointed stalks were the petrified vertebral columns of fishes; while some compared them to the siphuncles of Orthoceratites. It was not until 1719 that one Rosinus published the opinion that the Crinoids were the remains of animals closely allied to the Star-fishes, and endeavored to shew that they were provided with a stalk, notwithstanding their animal nature. When it is taken into consideration that at that time no living creature with a structure at all resembling the organism suggested by Rosinus was known, it is clear that such a view must have appeared quite extraordinary to most of the naturalists of the age. A correct theory however often precedes its confirmation, and forty-two years afterwards, or in 1761, a living encrinite, the *Pentacrinus caput-Medusæ*, was drawn up from the bottom of the sea with all its parts constructed exactly in

accordance with the ideas of Rosinus. From the date of this discovery it may be said that the animal origin of the fossil Crinoids was perfectly well established; but no advance was made towards their classification, upon principles deduced from the relations of the different parts of the skeleton, until 1821, when Miller published his work, "The Natural History of the Crinoideæ."*

In this work Miller shews that the calcareous plates which constitute the frame of an encrinite have a quinquepartite arrangement, or consist of five similar sets of plates, which, when spread out in a plane with the base of the cup for a centre, assume the form of a star with five rays. He also pointed out how the genera could be founded upon the various modifications of these rays and upon the number and position of the other plates, such as the sub-radials and inter-radials. Up to the present time scarcely any improvement has been made upon the generic system of Miller. The nomenclature devised by him however for the different plates has been found inconvenient, and others much more useful in application have been substituted. The rules for the construction and determination of genera used by all subsequent authors are essentially those of Miller, and to him, therefore, belongs the credit of having first correctly analyzed the skeleton of the Crinoideæ.

In June, 1835, the famous discovery of Thompson, that, in the young state, the *Comatulæ* so abundant in some of the existing seas are true Crinoids, was communicated to the Royal Society.† In that paper it was shewn that, at certain seasons of the year, the grooves in the pinnulæ of the rays of *Comatula Europæa* are filled with eggs to such an extent that the soft skin which covers the furrow becomes greatly distended, and that shortly afterwards the eggs are discharged and myriads of them distributed about upon sea-weeds, shells, and other marine objects. At first a short, thick stalk, supporting a small, club-shaped head, which exhibits only obscure indications of arms, springs from the deposited egg; but soon the stalk increases in length, the arms are unfolded, and a perfect Crinoid is thus produced from the egg of a *Comatula*. The form and structure so

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* A Natural History of the Crinoidea or Lily-shaped Animals, with observations on the genera *Asteria*, *Euryale*, *Comatula* and *Marsupites*. 4to. 50 colored plates. By J. S. Miller, A.L.S. Bristol, 1821.

† Memoir on the Star-fish of the genus *Comatula*, demonstrative of the *Pentacrinus Europæus*, being the young of our Indigenous Species. By John V. Thompson, F.L.S., Deputy Inspector-General of Hospitals. Communicated by Sir James McGrigor, F.R.S. Edinburgh New Philosophical Journal, volume xx., page 295.

much resembles the large West Indian *Pentacrinus*, that it was for several years thought to be a distinct species of that genus, and was in consequence called *Pentacrinus Europæus*. When further advanced the head, having assumed the form of a *Comatula*, separates from the stalk, and during the remainder of its life moves about through the ocean. As the highly important paper in which this wonderful fact was communicated to the world ought to be in the hands of every student of geology, and as also it is difficult to procure, I have published it entire, with copies of all the original figures, at the end of this Decade.

The next publication in which any great advance in the knowledge of the anatomy of the Crinoideæ was made appeared, in 1841, in the "Transactions of the Royal Academy of Sciences of Berlin." It was a paper entitled, "On the Structure of *Pentacrinus caput-Medusæ*,"* containing the observations made by the late Professor J. Müller while dissecting a specimen which had been captured in the West Indian seas and preserved in spirits. In this memoir Prof. Müller shewed that the grooves which extend from the mouth along the ventral surface to the bases of the arms, and are thence continued upon the arms to their extremities, are true ambulacra, closely allied to those of the Star-fishes. He also greatly improved the nomenclature of the different portions of the skeleton.

In 1854 MM. L. DeKoninck and H. LeHon issued an admirable work, entitled "Researches on the Crinoids of the Carboniferous Formation of Belgium,"† in which these excellent palæontologists give a most able review of the whole subject of the skeleton and classification of these fossils. They have improved the nomenclature, until it is now nearly perfect; and they also devised an ingenious formula, by the use of which all the leading characters of a genus can be expressed by a few words and figures. I shall make an application of this formula to all the Canadian genera. The work besides includes a catalogue giving the title, date of publication and author's name of every book or pamphlet known to contain any description or allusion to the Crinoids from the time of Agricola, in 1558, up to the year 1854. There are upwards of three hundred

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* Uber den Bau des *Pentacrinus caput-Medusæ*. (*Abhandlungen der Koniglichen Academie der Wisenschafften zu Berlin*, 1841, page 177.)

† Recherches sur les Crinoides du Terrain Carbonifère de la Belgique. Par L. DeKoninck et H. LeHon, suivies d'une notice sur le genere *Woodocrinus*. Bruxelles, 1854.

different works noticed; and to collect so great a mass of authority must have cost a vast amount of labor.

The above are the most important works containing information relative to the structure of the Crinoideæ founded upon the personal observations of the authors. The list of books, or periodicals with articles or papers describing new species or genera, is too extensive to be given in this place; and I shall therefore now proceed to notice in detail the different portions of the skeleton of the Crinoids, and to explain the meaning of the technical terms used in the subsequent portion of this memoir.

I. *The Column or Stalk.*

The column usually consists of a long and slender cylindrical stalk, composed of numerous short joints, so closely articulated together, that, during the life of the animal, it must have possessed a very considerable amount of flexibility. It seems probable that in species where the joints are alternately large and small, as in *Glyptocrinus*, there was a greater degree of pliancy than in those instances where it is formed of thin, equally large circular plates, as in the lower part of the appendage in *Rhodocrinus pyriformis*. In the Corniferous limestone smooth round columns one inch in thickness are often found, and these are so firmly constructed, that they must have stood upright, supporting the body of the Crinoid, as upon the top of a pillar. The columns are either pentagonal throughout their whole length, or pentagonal in one part and round in another, or altogether round and smooth. In all the species they are perforated from top to bottom by a small central canal, which is also either circular or pentagonal. This canal no doubt served the purpose of conveying the nourishment from the interior of the body to every part of the column, by which its growth was provided for. In nearly all Crinoids the lower extremity of the column was attached to the bottom of the sea or some other solid object, such as pieces of floating timber, either by a number of branching rootlets, as in *Rhodocrinus pyriformis*, or by a broad, solid base, as in *Cleiocrinus regius*. I think however that certain Lower Silurian species were free, and moved about through the water, dragging their columns after them. I have seen at least a hundred columns of *Glyptocrinus ramulosus* with the lower part preserved, and could never discover any signs of an attachment. In this species the column at the upper end is often half an inch in thickness, and it tapers gradually to half

a line at the lower extremity, a short piece of which, when found perfect, is always closely curled up, like a miniature coil of rope. I think also that sometimes the attached species had their columns broken off by some accident, and that the animal lived long afterwards free, but with a portion still connected with the body. I have seen specimens of *Rhodocrinus pyriformis* with from six to ten inches of the column attached to the base of the cup, with the terminal joint where the fracture occurred rounded, and the alimentary canal closed, or, as it were, healed up. There does not appear to be any way of accounting for this condition of the column, unless upon the above supposition.

The species of the genus *Comatula* now living, all of which are true Crinoids, are attached while young, but free in the adult state. The invaluable observations of Thompson on this genus will, as already stated, be found at the end of this Decade. The *Marsupites* of the Chalk which have no column were also free Crinoids.

II. *Side-arms or Cirri.*

The side-arms or cirri are long, slender-jointed appendages, attached to the column, the purpose of which does not appear to be well understood. They have not yet been found on any of the Lower Silurian species. Some of them are represented in the figures given at the end of this Decade, in the article upon *Comatula*.

III. *The Basal Plates.*

The base of the cup consists of a set of plates arranged in a circle on the top of the column, and in some species where they are large constitutes a saucer-shaped support for the viscera, to the centre of the bottom of which support the column is attached. This part of the skeleton has usually been called the pelvis. In nearly all the Lower Silurian species there are five basal plates; in the Upper Silurian, species with three or four are not uncommon; while in the Devonian those with five plates are comparatively rare.

IV. *The Sub-radial Plates.*

These are always five, and constitute a row resting upon the upper edges of the basals. They occur in the genera *Palæocrinus*,

Dendrocrinus, *Porocrinus*, *Carabocrinus*, *Rhodocrinus*, and others. In *Glyptocrinus*, *Heterocrinus*, *Thysanocrinus*, *Hybocrinus*, and *Cleiocrinus*, there are no sub-radials, the rays springing immediately from the basals.

V. *The Rays and Radial Plates.*

In all Crinoids there are five rays, the lower plates or extremities of which are included in the structure of the cup and form part of the shell, while the upper portions are prolonged above the body, and constitute the arms, which are generally free and more or less branched. In *Rhodocrinus* and *Glyptocrinus* each ray consists at first of a single series of three plates, sometimes called the primary radials or simply the radials; it then divides into two series, called the secondary radials. In these two genera the primary and secondary radials enter into the composition of the cup. In *Glyptocrinus* the first or lowest primary radials rest upon the upper edges of the basal plates, alternating so that each ray is supported by the contiguous sides of two of the basals. In *Rhodocrinus* there is a series of sub-radials between the basals and primary radials. In such genera as *Palæocrinus*, *Carabocrinus*, *Dendrocrinus*, and *Porocrinus*, the first primary radial only is included in the walls of the cup, but the second plate and all above it are free. In the very remarkable genus *Cleiocrinus* the primary, secondary, tertiary, quaternary and quinary rays are all firmly connected together, the free arms commencing with the sixth or seventh division.

The student will find many other modifications of the radial system of the Crinoideæ by consulting the works of various palæontologists; but the above are the more common ones, and those most prevalent in the Lower Silurian of Canada.

VI. *The Inter-radials.*

The divisional space between two rays is called an inter-radius; and as there are five rays, there must be of course an equal number of inter-radii. Four of these are always of equal size, and are called the "regular inter-radii," and when they contain plates these are designated the "regular inter-radials." The fifth is larger than either of the other four, and is called the "azygos inter-radius," from the Greek *azugos*, "unyoked," or "not paired." The plates in this inter-radius are called the azygos inter-radials. In most works the "azygos inter-radials" are termed "anal plates," but as they are

not anal plates, I think another name preferable. The *azygos interradials* always mark the anterior side of the animal, or that side towards which the mouth is most approximated. The posterior side is directly opposite, and indicated by the azygos ray. There are thus in every Crinoid two pairs of rays, the right and the left, and an odd or azygos ray. There are also two pairs of inter-radii, the right and left pairs, and an odd one, which is the azygos or anterior inter-radius. When a Crinoid is placed with its anterior side towards the observer, the left anterior ray is opposite his right hand and the right anterior ray opposite his left. Such genera as *Glyptocrinus* and *Rhodocrinus* have both regular and azygos interradials, but *Palæocrinus*, *Carabocrinus* and others of a similar structure, have only the latter.

VII. *The Mouth, the Ambulacral Grooves, and Ambulacral Orifices.*

The space on the upper part of the body surrounded by the arms is called the ventral surface, and, by some authors, the vault. It is covered with plates, which are usually smaller than those of the walls of the cup, and disposed without any observable order. The mouth is a circular or oval aperture, situated either in the centre of the vault or between the centre and the margin of the cup, towards the anterior side or below the margin in the side. It sometimes consists of a tube called the "proboscis," which rises from two or three lines to more than an inch above the surface. In some species, such as *Caryocrinus ornatus* (Say), it is closed by a valvular apparatus consisting of five or six small triangular plates. In *Pentacrinus caput-Medusæ* there is a central orifice, and, proceeding from it, five ambulacral grooves on the surface of the vault, which radiate outwards and divide into ten before reaching the margin. The ten grooves proceed straight to the bases of the ten secondary rays or free arms, and are continued upon them to their extremities. The main grooves send out branches to all the divisions of the arms and to each of the pinnulæ. The grooves throughout their whole length are covered over with a soft skin, through which there are numerous minute circular perforations arranged in two rows, one along each side of the groove. These orifices are supposed to be passages for the fluid which serves to extend or retract a set of small sucking feet which are visible on the outside, one over each orifice. The margins of the grooves are bordered by small erect moveable plates, which extend along the

sides like a fence of minute palings. These are the "*marginal plates* of the *ambulacral grooves*."

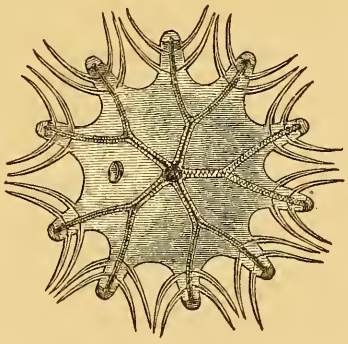

Figure 1.

Figure 1. Diagram of the ventral surface of *Pentacrinus caput-Medusæ*. The central orifice is supposed to be the mouth; the other, the anus. One of the grooves is represented as being closed over by the marginal plates.

The grooves are covered passages, along which are conveyed from the interior of the body to the arms and pinnulæ a number of tubular vessels whose functions appear to be of great importance in the physiology of the Crinoids. As the eggs from which the young are produced are developed in the pinnulæ, no doubt there must be an organ of some kind connected with their generation which communicates with the viscera of the animal by passing along the grooves. Another set of vessels are the aquiferous canals, consisting of long, slender tubes, for the conveyance of the fluid by which the sucking feet of the arms and pinnulæ are extended or retracted. To these must be added the blood-vessels, nervous filaments, and muscles. Traces only of these have been actually observed, but the almost perfect identity in structure between the ambulacra of the Crinoids and those of the Star-fishes, in which it is well known that such organs do exist, renders it quite certain that the former as well as the latter are provided with a full set of ambulacral vessels.

In many of the extinct species of Crinoids, although the arms and pinnulæ are grooved, yet there are no grooves leading from the bases of the arms to the mouth; and it therefore becomes probable that the ambulacral vessels of the arms and pinnulæ do not enter the body through that orifice. Indeed in a great many species, as the mouth is situated in the top of a tube which is sometimes longer than the arms and rises above them, it seems impossible that they

could gain access to the interior by that route. Accordingly a more direct passage is provided. In a great many species which have no calycinal grooves there is an aperture at the base of each arm in which the groove of the arm terminates. I think that in such species the ambulacral vessels, after descending from the extremity of the arms to the bases of the arms, pass directly into the body through these apertures. I have therefore, in Decade III., proposed to call these the "*ambulacral orifices*."

The genera in which they are most conspicuous are *Actinocrinus*, *Rhodocrinus*, and *Platycrinus*, but there is abundant evidence of their presence in a great many other genera. The subject of these orifices requires a good deal of investigation, as there appear to be many important modifications upon which our Canadian specimens throw no light. In fact all our Lower Silurian species are in such a bad state of preservation, that many years must elapse before the whole of their characters can be worked out. The principal variations in the position of these orifices exhibited by different of the Crinoids, are the following:—

1. Crinoids with the ambulacra continued from the base of the arms over the ventral surface to the mouth—no ambulacral orifices distinct from the mouth,—*Comatula*, *Pentacrinus*, *Palæocrinus*.

2. Crinoids with the ambulacra continued from the bases of the arms to a single ambulacral orifice in or near the centre—the mouth on one side—*Sphærocrinus*, *Crotalocrinus*, *Palæocrinus*, *Carabocrinus*.

3. Crinoids with an ambulacral orifice at the base of each arm, the mouth either central or between the centre and one side.

The following figures exhibit some examples of the variations in the position of the mouth and ambulacral orifices in different species:—

Fig. 2.

Fig. 3.

Fig. 4.

Figure 2. View of the ventral surface of *Sphærocrinus geometricus* (Goldfuss sp.). *m*, the mouth.

" 3. Ventral surface of *Rhodocrinus verus*. *m*, the mouth.

" 4. *Crotalocrinus*. (From Sir R. I. Murchison's *Siluria*, 1st edition, p. 219.)

In *S. geometricus* the space on the ventral surface surrounded by the arms is proportionally much smaller than it is in most other species. The arms stand in a circle which is one half the diameter of the cup. In the centre of this circular space there appears to have been no large plates. The arms are not placed on the edges of the primary radials, but near the centres of the plates, which have at the point of attachment of the arm in each a small perforation, supposed to be a passage for the brachial muscles. From these points shallow grooves proceed to the open space in the centre. The mouth is situated on one side, between two of the arms, as represented in figure 2, *m*.

In *Rhodocrinus* there are no grooves upon the ventral surface, and the mouth is at one side, between two of the arms (see figure 3, *m*). The ambulacral vessels must therefore have passed directly into the interior through orifices at the bases of the arms.

In *Crotalocrinus* the mouth appears to be central, and provided with an apparatus of small plates by which it could be opened or closed. The ambulacral grooves radiate from it, and divide twice or oftener before reaching the bases of the arms. There must be therefore at least twenty arms, one for each branch of the grooves. The grooves are provided with marginal plates, which are represented in the figure closed down, those of one side of the groove interlocking with those on the other side, and thus forming a roof-like covering over the ambulacral vessels.

SECTION II.

CRINOIDEÆ OF THE CHAZY LIMESTONE.

THE lower part of the Chazy group consists of sandstones, shales, and impure calcareous rocks, and the upper part of limestone, in general thick-bedded and densely crowded with organic remains. Some of the strata of this limestone are composed almost entirely of *Rhynconella plena*, others of several undescribed species of *Orthis*, while many of them are little else than compact masses of the comminuted remains of Cystideans and Crinoids.

There are at the present time known to be eleven species of Crinoids in this formation, and of these five will be characterized in the following pages; but of the other six we have as yet only the columns and some of the detached plates. Although we cannot determine the genera of these six species, yet it is quite certain that they are different, not only from those hereinafter described, but also from each other. None of the species are clearly identical with any that occur in either the Black River or the Trenton limestones, although one, *Hybocrinus pristinus*, is closely allied to *H. tumidus*, and may perhaps be a variety thereof.

The Crinoids and Cystideans of the Chazy appear to have been confined to a comparatively small area of the Silurian ocean. The grey limestone in which they occur is exposed in numerous localities on the islands of Montreal, Jesus, and Bizard, and in that tract of Silurian country which lies between the Ottawa and St. Lawrence rivers. It also extends from the island of Montreal southerly to the neighbourhood of Lake Champlain, and is largely exposed at the village of Chazy, the typical locality of the formation. This part of the formation has not been identified west of Kingston, nor so far east as Three Rivers. It lies therefore altogether within an area of about two hundred miles in length by one hundred in breadth. Outside of this area none of the Chazy Crinoids or Cystideans have been discovered.

Although for practical purposes it is most useful to treat of the Chazy as a formation distinct from that of the Birdseye and Black River limestone, yet the two deposits are most closely connected zoologically, since we find that, out of seventy-five species, about twenty, or more than one fourth, are common to both.

Blastoidocrinus carchariædens, Billings.

Plate I. Figures 1*a*, 1*n*.

Description.—Although the remains of the somewhat extraordinary species for which the above name is proposed are exceedingly abundant in the Chazy Limestone, and have for a long time attracted the attention of geologists, yet no specimens have been collected sufficiently perfect to enable us to make out the arrangement of all the parts. Indeed, so remarkable is the form of the principal plates, and so unlike any other fossils known in the Lower Silurian rocks, that, until very recently, no one has succeeded in shewing how they

could be brought together at all in such a manner as to constitute an organic structure. By several fortunate discoveries, however, of fragments of the body, with some of the plates still occupying their natural position, we are now in possession of data by which the more important details can be demonstrated, and no doubt other specimens will in course of time be found to supply the remainder.

The remains of this species most usually occur in an extremely comminuted state, and in such abundance that in many localities they constitute almost the whole of the ingredients of beds of solid rocks, of from six inches to three feet in thickness. Very frequently, where the rock has been long exposed to the action of the atmosphere, the large unbroken plates are weathered out and displayed in strong relief upon the surfaces of the strata; and as they are easily recognized and strictly characteristic of the Chazy limestone, they constitute a most valuable and safe guide to the explorer in tracing out the distribution of the formation, or in determining the age of isolated patches where other fossils may be absent, or where the test of superposition cannot be made available.

The form of these large plates is nearly triangular, two of the sides being straight or gently curved outwards, and the third more or less strongly arched inwards. This last mentioned side, when the plate is in its natural position in the perfect cup, is the lower side, and the angle immediately opposite to it the apex. The plates are not flat, but have a concavity extending from the apex downwards, being the deepest at the base, thus giving a form somewhat like that of an ordinary shoe-lifter. The length of the base measured in a straight line between the two lower angles, and, without following the curvature, is, in a specimen of the average size, about ten lines; the length of the other two sides, when compared with the base, is either equal to it or a little greater. The surface is ornamented with fine straight parallel striæ, from six to ten in the width of a line, and running in a direction from the base upwards. When the specimens are a little worn these striæ are obliterated, and the surface is then smooth or granular. The concave side of the plate is the outer side.

The specimen represented by figures 1*i*, 1*k* and 1*l*, Plate I., shews that the upper or ventral surface of the perfect fossil is divided into five equal portions by five rays or pseudambulacra, which radiate from the centre outwards, and that the place of the triangular plates above described is in the angles between the rays. There are thus five of these plates in the skeleton of each individual. The rays consist of two rows of narrow, elongated plates, placed transversely,

and which appear to be the homologues of the ambulacral plates of the rays in the genus *Pentremites*. The width of the rays near the centre is two lines, and there are four of the small transverse or ambulacral ossicula in the length of one line. The specimen does not shew the centre of the ventral surface, so that we cannot determine whether the mouth was situated there or not. In order to exhibit the analogy or affinity between this genus and *Pentremites*, I have had the following figures prepared :—

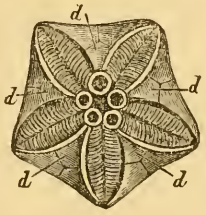

Fig. 5.

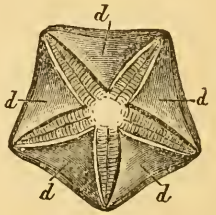

Fig. 6.

Figure 5. The ventral surface of *Pentremites pyriformis* (Say). *d*, the deltoid plates, extending only half the length of the pseudambulacra.

" 6. The ventral surface of *Blastoidocrinus carchariædens*. *d*, the deltoid plates, extending the whole length of the pseudambulacra. The unshaded space in the centre is most probably the place of the mouth.

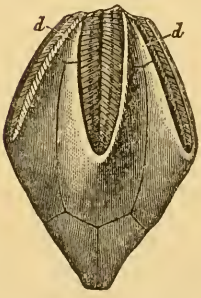

Fig. 7.

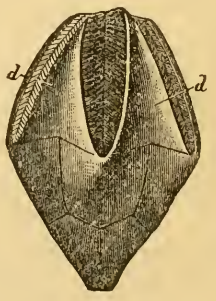

Fig. 8.

Figure 7. Side view of *P. pyriformis*.

" 8. The same, but with the deltoid plates extended to the extremities of the pseudambulacra, as in *B. carchariædens*.

From the above figures it appears quite probable that the large triangular plates of this species are the exact homologues of the deltoid plates of the *Pentremites*. If we imagine a pentremite with its deltoids so greatly developed that they would occupy the whole

of the spaces between the pseudambulacra, the structure would be exactly that of the upper surface of *Blastoidocrinus.*

From another specimen it appears that there are at least three, if not four or five, basal plates, and their form is remarkable, as they do not rest upon the upper surface of the upper joint of the column, as in the ordinary Crinoids, but have their inner edges turned upwards into the body of the cup, leaving a circular aperture in the bottom through which the column actually penetrates into the interior, nearly if not quite to the top of the visceral cavity. This is so extraordinary a structure that scarcely any palæontologist at all well acquainted with the organization of the Crinoideæ could be brought to believe it without personal inspection of the proofs. The two specimens in which the evidence is exhibited were discovered in two different localities. That represented by figures 1*i*, 1*k* and 1*l*, I found in a wall about half a mile west of the village of St. Laurent, on the island of Montreal; the other, figure 1*m*, in a quarry five or six miles east of the village. It is quite clear that they are not portions of the same individual. The St. Laurent specimen is part of an individual split in two from top to bottom, and exposing the interior exactly where the column should be found, if it penetrate through the base to the upper part of the visceral cavity, as above supposed. Such is its position in the specimen, as shewn in figure 1*l*. I at first thought that this might be the result of some accident; but having soon afterwards found the specimen represented by figures 1*m* and 1*n*, where a piece of the column is seen penetrating through the base, I believe it to be the natural arrangement. The column is round, with an alimentary canal so small that often the detached joints seem to have no central perforation. I have seen it however distinctly in a great many specimens. The flat faces of the separate joints exhibit strong radiating striæ. Thickness of column, two lines; and of the joints, from one fourth to half a line.

We often find associated with the remains of *B. carchariædens* some small fossils which appear to be the joints of a pentagonal crinoidal column. I have represented several of these by figures 1*o*, 1*p*, 1*s*, plate 1. They have five concave sides, and usually one end is rounded (see figure 1*s*), and the other generally flat, with five deep grooves radiating from the centre to the angles. In some specimens both ends are rounded; in many there is no central perforation, but in others there is. These are certainly crinoidal remains, but we have no means of shewing to what species or genus they belong.

Explanation of Figures. Plate I.

Figures 1*a*–1*h*. Deltoid plates of *B. carchariædens*.
" 1*i*. Side view of a specimen which has three of the rays partly preserved.
" 1*k*. The same, seen from above.
" 1*l*. Vertical section, shewing the position of the column in the interior.
" 1*m*. Fragment of the base, shewing the manner in which the column penetrates into the visceral cavity.
" 1*n*. Under side of 1*m*.
" 1*o*–1*s*. Small pentagonal crinoidal remains found associated with *B. carchariædens*.

Locality and formation.— Caughnawaga, Island of Montreal, Isle Jesus, Isle Bizard. Chazy limestone.

Pachyocrinus crassibasalis, Billings.

Plate I. Figures 3*a*, 3*b*.

Description.—Of the species for which the above name is proposed no perfect specimen has been found, and yet we have sufficient to shew that it belongs to a new genus. There are five small pentagonal basal plates concealed within the cavity for the attachment of the column. Above these and alternating with them are five very large and thick plates, which may be either sub-radials or first-radials. The lower portions of these plates are curved under the body, so as to constitute a broad, rounded or concave bottom to the cup, which has a width of nine lines at a height of about two lines. At this level the cup is broken off in the only specimen discovered, and we have no means of determining what was the structure above. There are no other Crinoids in the Lower Silurian rocks with a base like this, for although in the genus *Rhodocrinus* some of the species have a concave bottom, yet the sub-radial plates are always small and thin. It is true that mere difference in the size of organs or portions of an organic structure is not always of generic value; yet, where it is so extremely great as it is between the sub-radials of *Rhodocrinus* and the second series of this species, it is generally found that other differences exist sufficient to warrant a separation of the species in which such differences occur into distinct genera. I am inclined to believe, therefore, that when perfect specimens are found they will shew that this is a new genus.

Explanation of Figures. Plate I.

Figure 3*a*. View of the base of the specimen.
" 3*b*. Side view of the same.

Locality and formation.—Two miles north of Montreal, in the Chazy limestone.

Genus Hybocrinus, Billings.

(Hybocrinus, *Report Geological Survey of Canada*, 1856, page 274.)

Formula :

Basal plates, 5.	|	Azygos inter-radials, 2.
Radial plates, 1×5.	|	Regular inter-radials, 0.

Figure 9.

Figure 9. Diagram of the structure of the cup of the genus *Hybocrinus*.

Generic characters.—Cup, globular or pyriform, more protuberant upon one side than on the other, composed of five basal, five radial, and two azygos plates. The five basal plates are pentagonal, and alternating above them is a row consisting of one large azygos plate and four of the radials. The large azygos plate supports upon its upper right-hand sloping edge the second small azygos, and on the left the fifth radial. The arms in all the species that have yet been discovered are undivided, and each is composed of a single series of joints. The column is round and short. The generic name is derived from the Greek *hubos* (bent outwards or hump-backed).

Hybocrinus pristinus, Billings.

Plate I. Figure 2*a*.

Description.—This little species is usually about three lines in height and four lines in width, measured across the cup from the posterior to the anterior side. The anterior side is very protuberant, and the plates, although they appear smooth to the naked eye, yet, when a little magnified, are seen to be covered with small irregular tubercles. The arms are single and somewhat narrowly rounded on the back, the joints about one line in length. The column is round, half a line in thickness, and composed of joints which are, as far as

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Note.—In the expression radial plates, 1×5, the figure 1 indicates the number of plates in each primary ray, and the figure 5 the number of rays. In the diagram the shaded plates are the azygos inter-radials.

known, of an uniform size, there being on an average about ten in the length of two lines.

This species so closely resembles *H. tumidus* of the Trenton limestone, that I have had much doubt as to the propriety of separating it therefrom. The only differences that I can perceive are, that it is always smaller than the Trenton form, the plates more coarsely granulated under the lens, and not so convex in their centres. The column does not taper so rapidly, and it is composed of joints which are thicker in proportion. In a well-preserved specimen of *H. tumidus* the column exhibits from eight to ten joints in the length of one line, whereas in *H. pristinus* there are only five. Under these circumstances I have thought it best to distinguish the Chazy specimens by a separate name for the present.

Locality and formation.—Detached plates are rather common in the Chazy limestone at Caughnawaga, and at various localities on the Islands of Montreal, Jesus and Bizard; also in the front part of the Township of Hawkesbury. Perfect specimens are rare.

Genus PALÆOCRINUS, Billings.

FORMULA :

Basal plates, 5.	Azygos inter-radials, 1–3.
Sub-radial plates, 5.	Regular inter-radials, 0.
Radial plates, 1×5.	Calycinal ambulacra, 5.

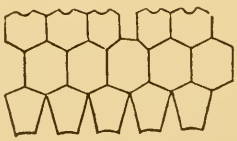

Figure 10.

Figure 10. Diagram of the cup of the genus *Palæocrinus*. The azygos inter-radial space is left blank in the figure, as it is not certain how many plates it contains.

Generic characters.—Cup, oval or pyriform, composed of five pentagonal basal plates, alternating above which are four hexagonal and one heptagonal sub-radial plates, and above these five radials bearing the free arms. The heptagonal sub-radial supports upon its truncated summit one, two, or three small azygos inter-radials. The rays are slender, and free from the second joint inclusive. There are five calycinal ambulacral grooves radiating from the centre of the abdominal surface to the bases of the arms, where there appear to be

also five small orifices leading to the interior. The mouth is probably situated near the margin, at the azygos inter-radius. Column, either round or pentagonal.

This genus belongs to that group of the Crinoideæ which includes such genera as *Cyathocrinus*, *Poteriocrinus*, *Dendrocrinus* and *Porocrinus*, to all of which it is closely allied in structure, but differs in the presence of calycinal ambulacral furrows.

Palæocrinus striatus, Billings.

Plate I. Figures 5*a*, 5*b*.

Description.—Cup, oval, gradually expanding from a small base to the width of five lines at the margin of a specimen seven lines high. The plates are depressed convex, and have a small round tubercle in the centre. They are also beautifully ornamented with radiating striæ or somewhat sharp, elevated ridges. One of these extends from the centre of each plate to the middle of each edge, and, crossing the suture at right angles, proceeds straight to the centre of the contiguous plate. Parallel with these principal ridges are four or five other shorter ones, also crossing the suture at right angles. Those nearest the principal ridge are the longest, and the length gradually decreases towards the angles. Where the ridges cross the suture, there are from three to five of them in the width of one line.

The only specimen collected shews very distinctly two ambulacral orifices at the bases of two of the arms, and two calycinal ambulacra leading therefrom towards the centre. The other three grooves are indistinctly indicated, but sufficient appears to leave little doubt as to their existence. The arms and column are unknown.

The plates of this species so closely resemble those of the cystidean *Palæocystites tenuistriatus*, that they can only be distinguished after much practice. The striæ on the surface of the latter species are always a little finer and of a nearly uniform size.

Explanation of Figures. Plate I.

Figure 5*a*. Posterior side of a nearly perfect specimen.
" 5*b*. Summit of the same, shewing the ambulacral orifices and grooves.

Locality and formation.—Somewhat common in the Chazy limestone at Caughnawaga and on the Island of Montreal.

Genus Rhodocrinus, Miller.

(Rhodocrinus, Miller, 1821. *Natural History of the Crinoideæ*, page 106.)

(Gilbertsocrinus, Phillips, 1836. *Geology of Yorkshire*, vol. ii., page 207.)

(Thysanocrinus, Hall, 1852. *Palæontology of New York*, vol. ii., p. 186.)

Formula :

Basal plates, 5.	Regular inter-radials, 6 to 8×4.
Sub-radial plates, 5.	Azygos inter-radials, 7 to 12.
Radial plates, 3×5.	

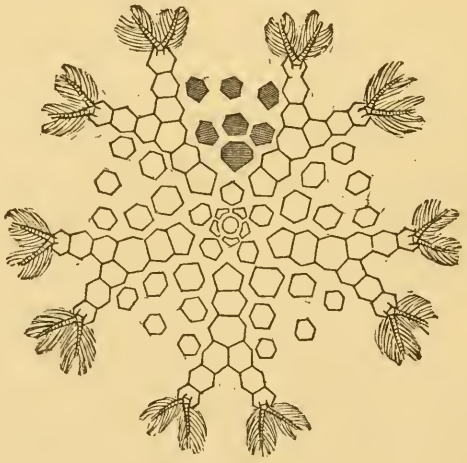

Figure 11.

Figure 11. Diagram of the structure of the cup in the genus *Rhodocrinus*.

Generic characters.—Cup, globular or oval; arms, long, often much branched, and densely fringed with pinnulæ; basal plates, five, alternating above which are five sub-radials; primary rays, five, consisting of three plates each; secondary rays, ten, the number of plates in each varying from one to four. The number of regular inter-radials varies from six to eight, while the azygos inter-radials are more numerous. The free arms spring from the secondary radials. In all the Canadian species the column is round, strongly annulated in the upper portion, and smooth below. The radix or base of attachment consists of a number of small, branching roots. The ambulacral orifices are situated at the bases of the arms, and the mouth, in all the species in which it has been observed, is excentric.

In the "Natural History of the Crinoideæ" Miller described this genus as having only three basal plates, an error into which it was easy for him to fall, on account of the minuteness of these plates in most of the species. In consequence of this mistake, several other genera were founded on specimens with five basal plates; but as it has been ascertained that Miller's original specimens have also five, these genera cannot be retained.

In the Report of the Geological Survey of Canada I referred with doubt two of our species, *R. pyriformis* and *R. microbasalis*, to the genus *Thysanocrinus* of Hall. They are very clearly congeneric with the *Thysanocrinus liliformis* of the Niagara limestone, while they have also in general the same structure as *Rhodocrinus*. There are however some differences in the form of the body and the upper parts which led me to think the genera might be distinct; but not being decided, I referred them to *Thysanocrinus*, at the same time giving the other name in a parenthesis. During the last summer I discovered the small species, *R. asperatus*, which has not only the structure but the aspect also of the typical forms of *Rhodocrinus*, and I think therefore that our three species should be placed in that genus.

Rhodocrinus asperatus, Billings.

Plate I. Figures 4*a*–4*e*.

Description.—Cup, small, nearly globular; surface covered with numerous small, conical, irregular tubercles. The basal plates are so exceedingly diminutive as to be entirely concealed within the cavity in the centre of the base in which the column is inserted. The column is round, and strongly and closely annulated near the base with very thin, sharp, projecting joints or rings, as in the other species of this genus. Judging from some fragments found associated with the specimen figured, it would appear that the arms are long and thickly fringed with well-developed pinnulæ. Height of cup in the only specimen discovered, six lines; diameter, the same.

Explanation of Figures. Plate I.

Figure 4*a*. Side view of the specimen.
" 4*b*. View of the base.
" 4*c*. A radix found in the same slab along with 4*a*.
" 4*d*. Portion of the surface of 4*c* magnified. The joints of this column appear to be composed near the root of five pieces each, which interlock, as represented in the figure 4*d*.
" 4*e*. Transverse section of the column near the root.

Locality and formation.—This species occurs in the Chazy limestone, in a quarry about two miles north of the City of Montreal. Exceedingly rare.

SECTION III.

CRINOIDEÆ OF THE TRENTON LIMESTONE AND HUDSON RIVER GROUP.

Although in almost every exposure of the Trenton limestone we find remains of the Crinoideæ, yet in general they consist of mere fragments, such as joints of the column or the detached plates of the cup. At the city of Ottawa they are found in a better state of preservation, but seldom perfect. Nearly all the species that we have been able to determine were collected at that locality; and as we know, from the researches of geologists in other countries, that these fossils are often confined to limited areas, it appears probable that few of ours will be found elsewhere.

The Hudson River species are so closely allied to the Trenton that I have not thought it necessary to describe them in a separate section.

Hybocrinus tumidus, Billings.

Plate II. Figures 1*a*–1*e*.

(H. tumidus, *Report Geological Survey of Canada*, 1856, page 275.)

Description.—Smaller than *H. conicus;* sub-globular, the plates tumid in their centres; column, slender and round, composed of thin joints, and tapering towards the base; surface of the plates, obscurely granular; length of cup, six lines; breadth at margin, about eight lines; arms, one line broad upon the back, composed of joints one line in length. Although about twenty heads of this species have been collected, none of them are quite perfect. They all are smaller and of a different form from *H. conicus.*

The ambulacral orifices in this species are indicated by a strong, narrow, rounded channel in the centre of the upper edges of the primary radial plates.

EXPLANATION OF FIGURES. PLATE II.

Figure 4*a*. View of the anterior side of a specimen, shewing the azygos plates.
" 1*b*–1*d*. Different views of other specimens.
" 1*e*. A polished transverse section just below the base of the arms, shewing the channels in the primary radial plates for the ambulacral orifices.

Locality and formation.—Trenton limestone; City of Ottawa.

HYBOCRINUS CONICUS, Billings.

Plate II. Figures 2*a*–2*b*.

(H. CONICUS, *Report Geological Survey of Canada*, 1856, page 274.)

Description.—In this species the cup is conical, with slightly ventricose sides; the base narrow, and the arms long and undivided; plates, smooth; height of cup, thirteen lines from the base on the azygos side to the upper margin; height of the opposite side, nine lines; length of the arms, three inches; the basal plates occupy more than one half the height on the azygos side and about one half on the others; the arms are one line and a half in width, broadly rounded on the back, and composed of a single series of joints, each one line in length; on their insides the ambulacral grooves are margined by rows of small plates resembling those upon the arms of some of the Cystideæ (*Pleurocystites*); about five of those plates to one joint of the arm. The column is round and smooth, consisting of very thin joints, ten to one line. The mode of attachment to the bottom was by a broad button-shaped base. Length of column in the largest specimen seen, one and three-quarter inches.

EXPLANATION OF FIGURES. PLATE II.

Figure 2*a*. Right side of a specimen of the average size.
" 2*b*. Left side of another specimen.

Locality and formation.—Trenton limestone, City of Ottawa.

Genus CARABOCRINUS, Billings.

(CARABOCRINUS, *Report Geological Survey of Canada*, 1856, page 275.)

FORMULA:

Basal plates, 5.	Regular inter-radials, 0.
Sub-radial plates, 5.	Azygos inter-radials, 3.
Radial plates, 1×5.	

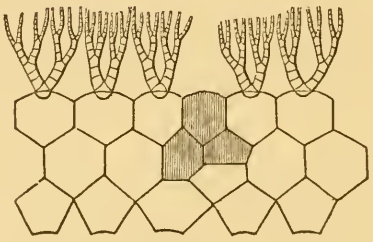

Fig. 12.

Figure 12. Diagram of the structure of the cup in the genus *Carabocrinus*.

Generic characters.—Cup, globular or ovoid; basal plates, five, four of them pentagonal, and the fifth hexagonal; sub-radials, five, three of them hexagonal, one heptagonal, and one pentagonal, the latter smaller than the others; primary radials, five, each bearing an arm which is several times divided. The azygos inter-radius is rather large, and occupied by three plates. One of them is supported upon the hexagonal basal plate; a second upon the small pentagonal sub-radial; the third is situated between the two anterior primary radials, its upper edge forming the margin of the cup, and its two lower sides resting upon two of the upper sloping sides of the first and second azygos plates.

Upon the ventral surface five calycinal ambulacral grooves radiate from the centre (where there appears to be an aperture) to the bases of the arms; the mouth is situated in the margin over the azygos plates; there is a small aperture, surrounded by an elevated border, half-way between the mouth and the centre. I think this small orifice is the anal aperture.

This genus is distinguished from the genera *Cyathocrinus* and *Poteriocrinus* by the depth to which the azygos inter-radials descend. In these two genera they are always situated above the sub-radials; but in *Carabocrinus* one of them stands upon one of the basal plates. The generic name is from the Greek *karabos*, a crab.

Carabocrinus radiatus, Billings.

Plate II. Figures 3*a*–3*e*.

(C. radiatus, *Report Geological Survey of Canada*, 1856, page 276.)

Description.—Cup, globose, rather broader at the margin than it is high; base, broadly rounded; surface, covered with strong rounded ridges, which radiate from the centres of the plates; arms, short, three times divided; column, round and slender, composed of alternately projecting thin joints. From the centre of each sub-radial plate two principal ridges ascend diagonally to the bases of the two arms on both sides; two others radiate to the centres of the two sub-radials on either side; and thus a series of triangles is formed round the upper half of the cup. In a similar manner ridges extend from the centres of the sub-radials to the centres of the basal plates, thus constituting another set of triangles in the lower half. Within each triangle, both in the upper and lower halves, are contained two or three smaller triangles, one within the other. In consequence of this arrangement, the ridges appear to radiate in groups of three or four.

Each arm-plate supports in its centre a small but stout pentagonal second radial plate, from the upper sloping edges of which spring two short round arms, which divide again at the second joint; these branches are again divided once or twice above. Height of the largest specimen, one inch; diameter at half the height, fourteen lines. Specimens are in the collection of all sizes, from three lines to twelve in diameter.

Explanation of Figures. Plate II.

Figure 3*a*. View of the anterior side, shewing the azygos inter-radius.
" 3*b*. Base of the same specimen.
" 3*c*. Posterior side of a different specimen.
" 3*d*. Ventral surface of a small individual. In the centre of the lower side of the figure is the mouth, and directly above it the small anal aperture.
" 3*e*. Ventral surface of a larger specimen, shewing obscurely the five ambulacral grooves. The three round darkly-shaded spots appear to be apertures accidentally produced.

For the fine specimen represented by figures 3*a* and 3*b*, we are indebted to Mr. Charles Wright, of Hull, Ottawa.

Locality and formation.—Trenton limestone; City of Ottawa.

Carabocrinus Vancortlandti, Billings.

Plate II. Figure 4.

Description.—Of this fine and rare species only one specimen has been seen, and that is unfortunately so much injured on the anterior side that the arrangement of the azygos plates cannot be determined. The form of the body is rather broad oval, the height being fifteen lines from the base to the margin, while the greatest diameter near the centre of the body is twelve lines. The base is narrowly rounded, and the cup expands gradually for about half the height, above which it contracts to the margin, where the width is about one line less than it is at the centre. The height of the posterior basal plate is five lines and a half, its greatest width four lines; the hexagonal basal, five lines high and about the same in width. Of the sub-radials, three are well-preserved; they are slightly narrower below than above. Height of the sub-radials, eight lines; width between the two upper lateral angles, seven lines, and between the two lower, five lines. The primary radials are each six and a half lines wide and five lines high. The arms are rounded on the back, and a little more than one line in thickness. They have each three single joints, the third being pentagonal and supporting upon its upper sloping sides two secondary rays, which are subdivided at the distance of two lines and a half.

The surface is ornamented with radiating ridges, as in *C. radiatus;* but the ridges are proportionally smaller and more distant from each other.

This species is clearly distinct from *C. radiatus*, from which it differs in being of an oval instead of a subglobular shape. In all the specimens of *C. radiatus* the width is greater than the height; while in *C. Vancortlandti* the height is greater than the width. It is also to be observed, that in the former the arms divide above the second free joint, and in the latter above the third.

The species is dedicated to Dr. E. Vancortlandt, of the City of Ottawa, whose zeal in the advancement of science has been productive of many beneficial results. The only specimen known belongs to his cabinet, and has been kindly communicated by him to us for description.

Explanation of Figures. Plate II.

Figure 4 exhibits a view of the posterior side of the specimen.

Locality and formation.—Trenton limestone; Township of McNab, near Arnprior.

Carabocrinus? tuberculatus, Billings.

Plate X. Figures 2*a*, 2*b*, 2*c*.

Description.—Cup, sub-globular or broadly oval; surface of plates covered with small, rounded tubercles; arms, large, long, several times divided; column, round, and in the upper part composed of alternately thick and thin joints.

Of this species we have only one specimen, and that is imperfect. The distinctive characters are the tuberculated surface and large arms. Although I have not seen the azygos inter-radials, yet the general aspect of the specimen is so much like that of *Carabocrinus*, that I have little doubt it belongs to that genus.

Explanation of Figures. Plate X.

Figure 2*a*. The only specimen collected.
" 2*b*. Three joints of the column, enlarged.
" 2*c*. One of the joints of the arms, enlarged.

Locality and formation.—Hudson River group, Charleton Point, Anticosti.

Genus Porocrinus, Billings.

(Porocrinus, *Report Geological Survey of Canada*, 1856, page 279.)

Formula:

Basal plates, 5.	Regular inter-radials, 0.
Sub-radials, 5.	Azygos inter-radials, 2.
Radials, 1 × 5.	

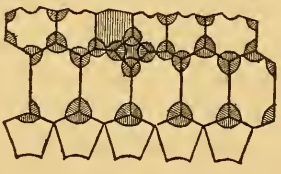

Figure 13.

Figure 13. Diagram of the structure of the cup in the genus *Porocrinus*.

Generic characters.—Cup, conical; basal plates, five, pentagonal; sub-radials, five, three hexagonal and two heptagonal; primary radials, five; one large azygos inter-radial, supported on the truncated summit of the anterior sub-radial, and one small one, situated

over the suture between the anterior and left anterior sub-radials, and having above it on one side the large azygos, and on the other the left anterior primary radial; several small pectinated rhombs, similar to those of the Cystideæ.

The characters of this genus are nearly the same as those of *Cyathocrinus*, *Poteriocrinus* etc., but differs from these and other allied genera in the presence of the pectinated rhombs. Only one species is known.

Porocrinus conicus, Billings.

Plate II. Figure 5*a*–5*d*.

(P. conicus, *Report Geological Survey of Canada*, 1856, page 279.)

Description.—Cup, one line and a half in diameter at the base, and gradually enlarging, with slightly ventricose sides, to the width of five lines at the margin; height, seven lines; basal plates narrow, nearly two lines high; sub-radials, three lines in height; first primary radials, about two lines and a half in height and breadth; all the plates smooth; column, circular, smooth, and suddenly enlarged near and up to the base of cup, composed of very thin joints; free rays, long, slender and single to their extremities; they are about half a line in thickness, and appear to be composed of a single series of joints. Only about one inch in length of the column next the base has been seen.

In this species there exists a number of poriferous areas resembling the pectinated rhombs of the Cystideæ in their structure, and probably adapted to the performance of the same functions. Their forms and position are however somewhat different from those of any known cystidean. In fossils of the latter order these organs consist of two parts, one situated upon each of two contiguous plates, but in this crinoid, each is so placed that it occupies the angles of three plates. Their form is that of an equilateral spherical triangle, and their size about one line in diameter. There are five situated at the apices of the five basal plates, five at the lower angles of the arm-plates, five at the apices of the sub-radials and five between the arm-plates on the margin of the cup. There are also two or three small ones at the angles of the azygos-plates, in all twenty-two or twenty-three. The pores consist of fine elongated parallel slits, which appear to penetrate through the plates; they are not at right angles to the margin of the plates as in the Cystideæ, but oblique.

The central pore of each division divides the angle into two equal portions, and all the other pores upon the plate are parallel to this central one; consequently in each area they have three directions in which they are at right angles to the sides of the triangular space in which they are situated, but oblique with respect to the margins of the plates.

EXPLANATION OF FIGURES. PLATE II.

Figures 5*a*, 5*b*. Posterior views of two specimens.
" 5*c*. Anterior side of a specimen, enlarged to shew the azygos plates and poriferous areas.
" 5*d*. Ventral surface of 5*a*.

Locality and formation.—Trenton limestone, City of Ottawa.

Genus DENDROCRINUS, Hall.

(DENDROCRINUS, Hall, *Palæontology of New York*, volume ii., page 193.)

FORMULA:

Basal plates, 5.	Regular inter-radials, 0.
Sub-radials, 5.	Azygos inter-radials, 1.
Radials, $1\times4+1\times2=6$.	

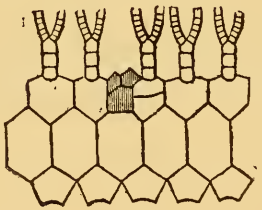

Fig. 14.

Figure 14. Diagram of the structure of the cup in the genus *Dendrocrinus*.

Generic characters.—In this genus there are five pentagonal basal plates, and alternating above these a series of five sub-radials, one of which has its superior angle truncated, and supports a large azygos inter-radial. There are five rays alternating above the sub-radials; the ray on the left-hand side of the large azygos inter-radial has two of its plates entering into the composition of the cup; this ray is free, from the third joint inclusive; of the other four rays, only the first joint is included in the cup. A large and long proboscis rises from the azygos inter-radial plate.

This genus is exactly the same in the composition of the test as *Cyathocrinus* with the exception of the peculiarity that one of the rays has two of its joints contained in the walls of the cup. In the original description given by Professor Hall, (Pal. N. Y., vol. 2, p. 193,) four series of plates are mentioned, including five "scarcely visible" plates beneath those which I regard as constituting the true base; they cannot be seen in any of the specimens in the collection of the Survey, although at least four of the species are unquestionable congeneric with *D. longidactylus* (Hall).

I have seen Professor Hall's specimens, and he agrees with me that the generic description may be so modified as to receive many species with the same structure in other respects, but which do not exhibit the small plates at the base. It will be seen by referring to fig. 7, c, plate 42, vol. 2 Pal. of New York, that the column of *D. longidactylus* consists of alternately large and small (or thin) joints, and that the latter sometimes consist of five divisions. Professor Hall is now of opinion that the small pieces at first regarded as constituting the true base are not of generic importance, and that they may be considered either as one of the quinquepartate thin plates of the column, or as a basal series so little developed as not to be of more than specific value.

It will be recollected by those who have studied the Crinoideæ, that a similar question relating to the base of *Poteriocrinus* still remains unsettled; Professor Philips and the Messrs. Austin having published that genus with three minute plates situated under the three basal plates.

Dendrocrinus gregarius, Billings.

Plate III. Figures 1*a*, 1*b*, 1*c*.

(D. gregarius, *Report Geological Survey of Canada*, 1856, page 265.)

Description.—Cup, acutely conical, from three to eight lines in length, and from two to six lines broad at the greatest diameter, which is at the margin, whence to the small pointed base it tapers uniformly with nearly straight sides; basal plates, narrow, nearly one third the height of the cup; sub-radials, rather more than one third broader than high; large azygos inter-radial, not quite so large as the plate on which it stands, broader above than below; proboscis,

for several lines above the azygos, nearly as wide as the cup, and composed of numerous small plates, which appear to be regularly arranged in upright rows; the arms bifurcate once immediatly after becoming free, and many times again above; they are very long and obtusely angular on the back. Below the first bifurcation there are about four joints, and they occupy a length of two lines in a specimen where the cup is six lines high and the arms two inches and one-fourth long. Their thickness in this part is about half the width of the first primary radial plates from which they spring, and they appear to hold a very deep groove on their inside, as the thickness is greater in that direction than it is in the other; the column is round, slender and flexible, slightly enlarging near and up to the base of the cup, and composed of alternately thick and thin joints, about six of each in a line of the length; the plates are without ornament.

This species so much resembles *D. longidactylus* (Hall) of the Niagara group that it can scarcely be separated. The principal differences consist in its smaller dimensions, and in the absence of the vertical ridges along the proboscis. On comparing with the illustrations given in the Palæontology of New York, it will be seen that the second plates of the rays on each side of the proboscis are in fig. 1*a*, plate 43, broader than those upon which they rest. In our specimens the second plate of the left-hand ray is equal to the first; in the right-hand ray it is a great deal less, agreeing in this respect with fig. 7*a*, plate 42. The species are closely related, and yet I am satisfied they are different.

EXPLANATION OF FIGURES. PLATE III.

Figure 1*a*. Posterior view of a specimen.
" 1*b*. The left side.
" 1*c*. Column, enlarged.

Locality and formation.—City of Ottawa, in the central part of the Trenton limestone.

DENDROCRINUS ACUTIDACTYLUS, Billings.

Plate III. Figures 2*a*, 2*b*.

(*Report Geological Survey of Canada*, 1856, page 266.)

Description.—Cup, small, conical somewhat pentagonal; arms, very slender, several times sub-divided and excessively sharp on the back; column, round, composed of small nearly globular joints;

length of cup in the specimen examined, two lines, breadth at base of free rays, the same; length of free rays, one inch and one-eighth; thickness upon the back below the first sub-division, about one-fifth of a line. At three-fourths of an inch below the base of the cup there are five joints of the column to one line in length. The two arms visible in the specimens bifurcate at the fourth free joint, and three times again at varying distances above. Only one side of the specimen can be seen, yet the characters of the cup and arms are so similar to those of the last species that there can be little doubt of its generic affinities while the globular joints of the column and the thin sharp backed arms are characters sufficient to separate them specifically.

EXPLANATION OF FIGURES. PLATE III.

Figure 2*a*. Posterior side of a specimen.
" 2*b*. Portion of the column, enlarged.

Locality and formation.—Upper part of the Trenton limestone, near the Toll-gate, St. Lawrence Street, Montreal.

DENDROCRINUS PROBOSCIDIATUS, Billings.

Plate III. Figures 3*a*, 3*b*, 3*c*.

(D. PROBOSCIDIATUS, *Report Geological Survey of Canada*, 1856, page 267.)

Description.— Cup, small, conical sub-pentagonal; proboscis, enormously large in proportion to the size of the cup; column, pentagonal with raised edges along the five angles, and with concave faces between, composed of very thin joints, twenty-four in the length of two lines; the arms are thin and sharp on the back. In a specimen, the crushed cup of which is three lines in length, there is a proboscis attached, sixteen lines in length; the portion seen is of a very remarkable structure; it is composed of four vertical rows of small plates, with a strong central keel running up each row, from either side of which projects, nearly at right angles, a pair of short ridges to the outer side of each plate, giving to the surface the appearance of several small rope ladders side by side, as in the rigging of a ship. This peculiar style of ornament is well shewn in the figures of *D. longidactylus* (Hall), Pal. N. Y., vol. 2, fig. 7*a*, plate 42, but the pattern is somewhat different; in that species the transverse ridges diverge from each other at an angle of about 45

degrees, but in this the divergence is only about 20 degrees, producing to the eye a very different effect.

EXPLANATION OF FIGURES. PLATE III.

Figure 3*a*. Anterior side.
" 3*b*. Part of surface of proboscis, enlarged.
" 3*c*. Portion of column, enlarged.

Locality and formation.—Upper part of the Trenton limestone, near the Toll-gate, St. Lawrence Street, Montreal.

DENDROCRINUS HUMILIS, Billings.

Plate III. Figure 4.

(D. HUMILIS, *Report Geological Survey of Canada*, 1856, p. 270.)

Description.—Cup small, conical; arms, nearly as broad as the first primary radials, divided at the fourth or fifth joints, and again above; the basal plates are small, their height about equal to their width, the sub-radials three times larger than the basal plates; the first primary radials are low and broad; column, unknown; height of cup, two and a half lines, breadth at the margin, the same.

EXPLANATION OF FIGURES. PLATE III.

Figure 4. Posterior view of the only specimen discovered.

Locality and formation.—Trenton limestone, City of Ottawa.

DENDROCRINUS LATIBRACHIATUS, Billings.

Plate III. Figures 5*a*, 5*b*, 5*c*.

(D. LATIBRACHIATUS, *Report Geological Survey of Canada*, 1856, page 270.)

Description.—This species is most closely related to *D. humilis*, the only difference being in the greater breadth and length of the arms, which at the base are quite as wide as the first primary radials, and become a little broader above, whereas in the other species they become narrower from the base upwards. The bottom of the cup is more rounded than in *D. humilis*, and as the columns of both are unknown and as they occur in different formations, they cannot be easily identified at present; the arms are three times divided; length of cup, three lines and a half; of the arms, ten lines.

EXPLANATION OF FIGURES. PLATE III.

Figure 5*a*. View of the left side, shewing the left anterior ray, which has the first and second primary radials included in the cup.
" 5*b*. View of the anterior side.
" 5*c*. The posterior side.

Locality and formation.—Hudson River group, Charleton Point, Anticosti.

DENDROCRINUS SIMILIS, Billings.

(D. SIMILIS, *Report Geological Survey of Canada*, 1856, page 267.)

Description.—Cup, small, conical and sub-pentagonal; arms, long, three or four times sub-divided, rather broadly rounded on the back, and comparatively stouter than those of any of the above described species. Of the two arms preserved in the specimen examined, one remains single for a distance of two lines and a half, and then divides; there are five joints in the undivided part; the other arm shews but two joints in the part below the first bifurcation. The column for seven lines below the basal is pentagonal, with round edges and slightly concave faces; it is composed of alternately thick and thin joints, nine of each in the space of two lines, diameter of column nearly one line; length of arms sixteen lines, and the diameter at the undivided part nearly a line on the back.

Locality and formation.—Trenton limestone, City of Ottawa.

The last three species appear at first sight to be identical, but the moment a magnifying glass is brought to bear upon them, their differences become quite as apparent as those of the large species. In *D. acutidactylus* the arms are exceedingly thin and sharp on the back above the first division like the edge of a knife, and the column is circular and composed of round edged joints, which at the distance of one-half or three-fourths of an inch become nearly globular. In *D. proboscidiatus* the column at the base of the cup is pentagonal with the angles so strongly projecting, and the faces so concave that a single joint has the form of a five-rayed star; the arms, judging from the fragments seen, were very similar to those in *D. acutidactylus*.

In *D. similis* the column is only different from that of *D. proboscidiatus* by the unequal thickness of the joints, and in being more regularly pentagonal; its faces are only slightly concave, its arms also are five times thicker.

Dendrocrinus rusticus, Billings.

Plate III. Figures 7*a*, 7*b*.

(D. rusticus, *Report Geological Survey of Canada*, 1856, page 270.)

Description.—The base of the cup in this species is broad, like that of *D. conjugans;* the basal plates about as high as they are wide, the sub-radials one-third higher than the basal plates; the arm-plates a little shorter than the sub-radials, and broader than high; the azygos inter-radial is about the size of one of the basal plates, and bears three or four small plates upon its summit; the column is round at its junction with the basal plates, and composed of thin plates; but one line and a half below it becomes pentagonal, with raised rounded edges and concave faces; at the distance of two inches below the base there are about three joints of equal thickness to one line in breadth; the arms appear to have been short; breadth of cup, two lines and a half in one specimen and three lines in another; height of latter to the top of the inter-radial, four lines and a half; the whole surface is smooth. The specimens examined are imperfect, but to each there are about three inches of the column attached.

Explanation of Figures. Plate III.

Figure 7*a*. A specimen very imperfect.
" 7*b*. A small portion of the column, enlarged.

Locality and formation.—Trenton limestone, City of Ottawa.

Dendrocrinus conjugans, Billings.

Plate IV. Figures 1*a*, 1*b*, 2*a*, 2*b*.

(D. conjugans, *Report Geological Survey of Canada*, 1856, page 268.)

Description.—In this species the column about one inch below the base is round, smooth, and from half to two-thirds of a line in diameter; proceeding upwards it rapidly enlarges to two or three lines, at the base of the cup, which is small, and not much broader at the

margin where the arms become free, than it is at the bottom; the basal plates are low and broad, the sub-radials double the height of the basals and the arm-bearing plates rather more than two thirds the length of these latter; the arms half the breadth of the plates on which they stand, and broadly rounded on the back; they all divide at the height of about three lines, and again at the same distance above; there are three or four joints in each of the undivided portions. The ray on the left-hand side of the base of the proboscis, which in the generic description is said to have two of its plates included in the cup, in this species has the second plate free, with the exception that it is united on one side to the plates of the proboscis; it is however nearly as broad as the first radial plate upon which it stands, and one-third wider than the first free joint of the arm which rests upon it. This character connects *Dendrocrinus* with *Cyathocrinus*, in which the second joint of the ray in question is entirely free. The column as before mentioned is circular, broad at the base of the cup, and rapidly diminishing in size for a short distance below; it is in this part smooth, but farther down enlarges again, and is composed of thick round-edged compressed spheroidal joints very similar to those of *Heterocrinus Canadensis*. In one perfect specimen the height of the cup is three lines, the diameter of base two lines and a half, and at the margin three lines and a half; length of the arms to first division three lines and a-half, to second division six lines; width of arm to second free joint one line, and of the proboscis the same. In another individual this organ is wider than the arm; in a third specimen the arms divide at the fifth joint, but in every other respect it is the same as this species, although slightly more slender.

EXPLANATION OF FIGURES. PLATE IV.

Figure 1*a*. Anterior side.
" 1*b*. Column, a little enlarged.
" 2*a*. Side view of a specimen.
" 2*b*. Column of same, enlarged.

Locality and formation.—Trenton limestone, City of Ottawa.

Dendrocrinus Jewettii, Billings.

Fig. 15.

Figure 15. View of the anterior side of *Dendrocrinus Jewettii.*

Description.—Cup, conical, six lines in height; arms, large, several times sub-divided, broadly rounded or sub-carinate on the back. The plates are all more or less convex, and appear to have a set of obscure radiating ridges arranged as follows: 1st. On each of the basal plates there are two ridges which run from the centre of the plate upwards, and are continued to the centres of the two sub-radials that rest upon its upper sloping sides. 2nd. On each of the sub-radials there are four ridges, two of which are the continuations of the ridges from the basal plates, while the other two run from the centre of the plate upwards, and are continued on the first primary radials to the bases of the arms. The rays consist each of one large joint, included in the cup, and four smaller ones, above which they are divided. The large joint of the left anterior ray is hexagonal; the same joint in each of the other four rays is pentagonal. The azygos sub-radial is heptagonal, and supports upon its upper side a hexagonal azygos inter-radial, which, in its turn, supports the proboscis. Column, unknown. Height of basal plates, two lines; width at base of each, one line; width measured between the two upper lateral angles, one line and a half; height of sub-radials, three lines; width of first primary radial, two lines and a half; height, two lines; the four succeeding joints of the arms are each half a line high.

This species is allied to *D. humilis* and *D. latibrachiatus*, from both of which it differs in having the plates convex and ridged.

It was discovered by Col. E. Jewett, of Utica, N. Y., and by him kindly communicated to us for description. Through the researches of this gentleman our knowledge of the Silurian fauna of North America has been greatly extended. Many of the most rare and interesting fossils figured in Hall's Palæontology of New York are his discoveries; and it gives me much pleasure to dedicate this new crinoid to him.

Locality and formation.—Bay of Quinte, Trenton limestone.

Dendrocrinus cylindricus, Billings.

Plate III. Figures, 8*a*, 8*b*.

Description.—Cup, small, two lines and a half in height, and about the same in width at the margin; arms, cylindrical, one line in width at the base, divided above the third free joint; length of the undivided portion, two and a half lines, each one of the three free joints being nearly one line in length. The proboscis is large, equal to the arms in height, and composed on the anterior side of large plates, the first, second, third and fourth of which are each rather more than one line in length. All the plates are smooth. The column is round, smooth, and composed of very thin joints, which however vary a little in thickness, ten in the length of one line. Length of body and arms, one inch and one-fourth.

The above description of the column of this species refers to the upper portion only. It seems probable that in the lower part it is composed of thick, rounded joints, as I find a fragment of a column of this latter character on the same piece of stone in which the crinoid is imbedded.

Explanation of Figures. Plate III.

Figure 8*a*. Anterior side of *D. cylindricus*. That which appears to be a large arm near the left side is the proboscis.

" 8*b*. Part of the column, a little enlarged.

Locality and formation.—Near the Toll-gate, St. Lawrence Street, Montreal; Trenton limestone.

Palæocrinus angulatus, Billings.

Plate III. Figures 6*a*, 6*b*.

(Dendrocrinus angulatus, *Report Geological Survey of Canada*, 1856, page 269.)

Description.—In this beautiful little crinoid the plates are ornamented with radiating ridges similar to those of *Glyptocrinus decadactylus*. The cup is small, conical and pentagonal. From the centre of each of the rather large sub-radial plates there proceed six strongly-elevated ridges, one to the base of each of the two arms above the plate, one to each of the two basal plates below it, and one to each of the adjoining sub-radials. The arms are very slender, sharp on the back, and at least twice divided; the three joints of the column which remain attached to the specimen are pentagonal. Length of cup, three lines; breadth at the margin, four lines. Diameter of column, nearly one line.

Explanation of Figures. Plate III.

Figure 6*a*. Left side of the only specimen discovered.
" 6*b*. Column, enlarged.

Locality and formation.—Trenton limestone, City of Ottawa.

Palæocrinus rhombiferus, Billings.

Description.—This species is of nearly the same shape as *P. angulatus*, but differs in the arrangement of the surface-markings. In *P. angulatus* the radiating ridges are so disposed as to encircle the body with two horizontal rows of triangular spaces. In this species however, in consequence of the absence of the transverse ridges near the centre of the body, the spaces are rhomboids instead of triangles. The ridges are also so broad in the base that the separate plates appear to be simply bevelled from the centre to the edges. The detached plates figured on plate 4, vol. i. Palæontology of New York, under the name of *Actinocrinus*, resemble the sub-radials of this species, but are larger. Only one specimen has been collected, consisting of a perfect cup imbedded in a piece of limestone. The arms are sharp-edged on the back, and twice divided. Length of cup, three lines; and of the arms, nine lines.

Locality and formation.—Trenton limestone, City of Ottawa.

Palæocrinus pulchellus, Billings.

Description.—The same as *P. angulatus*, but with a round column. The surface of the specimen is a good deal eroded, and yet it can be seen that the surface is radiated, as in *P. angulatus*. The column is well preserved, and is one line wide at the base of the cup, from which point it rapidly tapers to the thickness of half a line at the length of four lines. Length of cup, three lines.

Locality and formation.—One specimen from the Trenton limestone, City of Ottawa.

Genus Lecanocrinus, Billings.

(Lecanocrinus, Hall, *Palæontology of New York*, volume ii., page 199.)

Formula :

Basal plates, 3.	Radials, 1×5.
Sub-radial plates, 5.	Azygos inter-radials, 1–3.

Generic characters.—In this genus there are three basal plates, one of them pentagonal and the other two hexagonal; in the second series there are five sub-radial plates, two of which are supported by the two hexagonal basal plates, while the other three alternate with these latter. Alternating above the sub-radials are five primary rays of three joints each, and above these, ten secondary rays. Some of the species have several small inter-radial plates in one or more of the divisions between the primary rays.

I have placed the following species in the above genus, although it appears probable that some other disposition should be made of them. The specimens are not sufficiently perfect to enable me to make out all the characters; and as they are more nearly related to *Lecanocrinus* than any other Silurian genus, it seems to be the better course to arrange them in that group provisionally.

Lecanocrinus elegans, Billings.

Plate IV. Figures 4*a*, 4*b*.

(L. elegans, *Report Geological Survey of Canada*, 1856, page 278.)

Description.—Cup, small, conical, three lines in height from the base to the upper margin of the first primary radial plate, at which level the breadth is also about three lines; the breadth of the base is one line and a half, and the top of the column scarcely less; the first primary radials are a little broader than high, and rendered slightly heptagonal by the truncation of their upper lateral angles; the second primary radials are narrower and quadrangular, or obscurely hexagonal; the third are pentagonal; the length of each is about a line and a half. The third in each of the three rays exposed in the only specimen seen, supports two secondary rays of five joints each, and then divides into two tertiary rays; these latter are again divided. The rays above the fourth division are articulated in two series. Between the primary rays are several small interradials. The column is circular, with round-edged joints, from four to six in one line; length of ray from the base of first primary radial to the extremities, one inch and one fourth.

Explanation of Figures. Plate IV.

Figure 4*a*. A specimen shewing one of the hexagonal basal plates.
" 4*b*. Several joints of the column, a little enlarged.

Locality and formation.—Trenton limestone; City of Ottawa.

Lecanocrinus lævis.

Plate IV. Figure 3*a*.

(L. lævis, *Report Geological Survey of Canada*, 1856, page 278.)

Description.—This species is shorter than the preceding, and has only four joints instead of five in the secondary rays; the upper part of the column is round and smooth. In other respects there is much resemblance between the two, but still I think them distinct.

Explanation of Figures. Plate IV.

Figure 3*a*. A specimen slightly crushed.

Locality and formation.—Trenton limestone; City of Ottawa.

Genus Heterocrinus, Hall.

(Heterocrinus, Hall, *Palæontology of New York*, volume i., page 278.)

Fig. 16.

Figure 16. Diagram of the structure of the genus *Heterocrinus*.

Generic characters.—The species of this genus are small, and, including the arms, long and nearly cylindrical crinoids. The base is composed of five plates, above which are five long rays, without any intervening sub-radial plates. The number of radial plates in each ray is variable. The cup appears to consist of the primary radials, while the free rays or arms commence with the first plates of the secondary rays. There are one or two small azygos inter-radials, but no regular inter-radials. The arms are pinnulated.

Heterocrinus Canadensis, Billings.

Plate IV. Figs. 5*a*–5*d*.

(Compare *H. simplex*, Hall, *Palæontology of New York*, volume i., page 280.)

Description.—Sub-cylindrical or elongated, fusiform; length, including the rays, from one to two inches; diameter at half the length, from three to four lines. The base in the large specimens is about one line and a half in diameter, and the body gradually enlarges to about three lines at that point where the rays divide. The diameter above is always greater, the extent depending upon the amount of expansion of the rays in the particular specimen examined. The basal plates are scarcely a line in height; the length of the undivided portions of the rays in the large individuals is about three lines.

The right anterior ray consists of three joints, the first equal in length to the other two, and with one of its angles truncated where it is in contact with the azygos inter-radial. The left anterior ray has four joints, the second being the longest, and having one of its angles truncated to support the inter-radial. The other three appear to consist each of four equal joints. The upper joint of each ray is pentagonal, and supports two secondary rays, which continue single to their extremities. The azygos inter-radial is oblong, higher than wide, five-sided, two of the sides meeting to form an obtusely-pointed lower extremity, which rests wedge-like between the truncated angles of the first joint of the ray upon the left, and the second joint of the ray on the right; its upper side is horizontal and supports another plate, which is probably the base of a proboscis. The secondary rays, ten in number, consist each of a series of oblong, quadrangular joints, usually one line in length and two-thirds of a line in breadth.

There is a row of long pinnulæ upon each of the inner margins of each ray; they rise upwards, nearly parallel with the rays, instead of projecting at nearly right angles, as in other species. The column is round and smooth at the base of the pelvis, below which it tapers and becomes very slender at the distance of one or two inches, then slightly larger and composed of compressed globular joints, the rounded edges of which, to the eye, present a bead-like appearance. The longest column seen with the head attached was fifteen inches; and, as it was broken off below, it had been probably several inches longer. The diameter is usually somewhat less than a line, and there are about seven joints of equal size to two lines in length. The smooth, slender, upper portion of the column, near the base of the cup, is generally half a line or a little more in diameter, expanding to twice or three times this size at the base.

H. simplex, according to Professor Hall, has the column at the base of the cup pentagonal, but is otherwise closely allied to *H. Canadensis*. (See description of *H. simplex* in the Palæontology of New York, volume i., page 280.)

EXPLANATION OF FIGURES. PLATE IV.

Figure 5*a*. A specimen with part of the column attached.
" 5*b*. Portion of the column, enlarged.
" 5*c*. Anterior side of a different specimen.
" 5*d*. A specimen which has the pinnulæ preserved.

Locality and formation.—Trenton limestone, Ottawa and Montreal.

Heterocrinus tenuis, Billings.

Plate IV. Figures 6*a*–6*b*.

(H. tenuis, *Report Geological Survey of Canada*, 1856, page 273.)

Description.—Much smaller than *H. simplex;* arms, long, very slender, and several times divided; column, very obscurely pentagonal, composed of sub-globular joints; proboscis, extending nearly to the apices of the arms; length, including the arms, from ten to sixteen lines; without the arms, from one and a half to two and a half lines; diameter at base of arms, about two lines; of column, at base of cup, half a line.

It is not certain that this species should be referred to the genus *Heterocrinus.* The plates of all the specimens in the collection are so closely united that their number and arrangement cannot be satisfactorily made out. The weight of the evidence is in favor of the genus under which I have placed it. The species, when several times attentively examined, is easily distinguished from *H. simplex.* In that species the column, for a short distance below the cup, is smooth and slender, and it enlarges suddenly from a few lines below, until it forms rather a broad base for the pelvis to stand upon. But in *H. tenuis* the column continues moniliform to the base of the cup and without enlarging, but on the contrary is rather less in diameter at the point of contact than it is below. In one specimen there are forty two joints in the first nine lines from the pelvis, and some irregularities in the size can be seen. They are thinner near the cup and gradually become thicker, so that at two inches from the pelvis there are only sixteen in half an inch. The arms, although much more slender than those of *H. simplex*, usually lie folded together, or but slightly separated.

Explanation of Figures. Plate IV.

Figure 6*a*. A specimen with part of the column.

" 6*b*. A few joints of the column, enlarged.

Locality and formation.—Trenton limestone, Ottawa and Montreal.

Heterocrinus inæqualis, Billings.

Plate IV. Figure 7*a*.

Description.—Cup, pointed at the base; rays, large, rounded on the back, and inequally divided. In the specimen figured, the two first primary radial plates which can be seen are long and nearly triangular, their lower acute angles meeting in the base of the cup and their upper straight sides supporting free rays or arms. Only three of the rays are visible in the specimen, the others being imbedded in the matrix. One of these (partly shewn at the left side of the figure,) appears to be simple or undivided throughout. It is nearly cylindrical, and consists of a series of large, transversely oblong joints, one line and one fourth in width and two thirds of a line in height. Its lower extremity is concealed, and I have not been able therefore to ascertain whether or not it originates in the base of the cup. The central ray (of the figure) divides above the third joint into two equal secondary rays, which are also several times subdivided. In these subdivisions of the secondary rays, however, the branches are of an unequal size, one of them in each instance being about one-fourth the thickness of the other. The other ray (partly exposed in the specimen,) is undivided from the base to the fifth joint inclusive, above which it is buried in the stone. The surface is minutely granular.

I have placed this remarkable species in *Heterocrinus* provisionally, as it most resembles species of that genus. When its structure shall have been ascertained, it may be necessary to refer it to some other genus.

Locality and formation.—Trenton limestone, Ottawa.

Heterocrinus articulosus, Billings.

Plate IV. Figure 8.

Description.—Of this species we have only a single ray, which much resembles one of the rays of *H. inæqualis*, but is nevertheless decidedly distinct. The secondary rays are irregularly jointed, the plates where the branches are given off being broader than elsewhere. In consequence of this character the rays have a peculiarly knotty appearance. It is probable that this species and *H. inæqualis* will, when all their characters are known, constitute a new genus.

Locality and formation.—Trenton limestone, Ottawa.

Genus Cleiocrinus, Billings.

(Cleiocrinus, *Report Geological Survey of Canada*, 1856, page 276.)

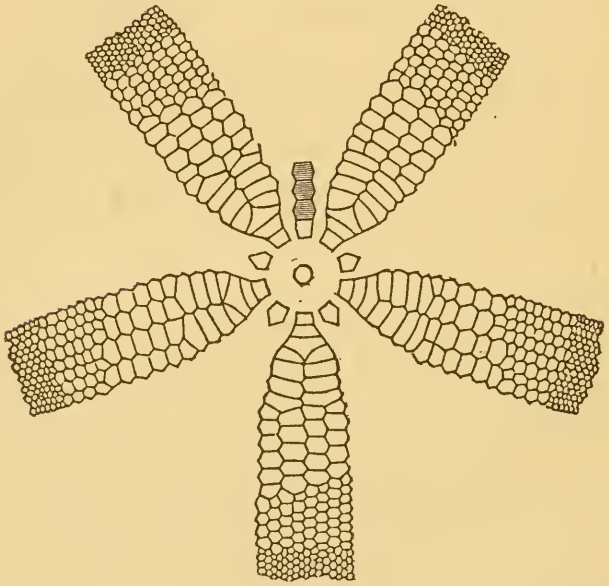

Fig. 17.

Figure 17. Diagram of the structure of the cup in the genus *Cleiocrinus*.

Generic characters.—Cup, large, conical or pyriform; basal plates, five; rays, five, alternating with the basal plates; the third plate of each ray is pentagonal and bears two secondary rays, which are several times divided above. Between two of the rays a single vertical series of azygos inter-radial plates extends from the base to the margin of the cup. The azygos plates and rays are all firmly anchylosed together by their lateral margins up to the height of the fifth or sixth sub-division. The column is pentagonal or nearly round.

This genus has the structure of a *Pentacrinus*, with numerously divided arms all soldered together in the walls of the cup.

Cleiocrinus regius.

Plate V. Figures 1*a*–1*g*.

(Cleiocrinus regius, *Report Geological Survey of Canada*, 1856, page 277.)

Description.—Cup, elongate, conical, gradually expanding from the base until near the top, where it is slightly contracted. The margin supports about forty long, very slender, tentaculated, free rays. At first sight there appear to be ten small basal plates, but upon examination five of these are found to be the first plates of the five rays which rest immediately upon the upper joint of the column; the other five are the true basal plates. Four of these latter are pentagonal, and the fifth, which supports the series of inter-radials, is nearly square; height of each basal plate, one line; breadth, the same; the small radial plates which rest on the column between the basal plates are a little broader than these latter, but not so high; the column is pentagonal, and the basal plates are placed upon the angles of the upper joint, while the bases of the rays are situated upon the straight edges: there are about two joints of the column to one line, and they are alternately thicker and thinner; the column near the lower extremity becomes round and suddenly expands into a broad base of attachment.

The surface of the cup is nearly smooth, slightly marked by obscure, vertical, rounded ridges along the centres of the rays and of their sub-divisions.

Length of cup, one inch and three-fourths; breadth near the margin, about one inch; diameter of column, from two to four lines. Nearly all the large pentagonal columns in the Trenton limestone at the City of Ottawa belong to this species.

Explanation of Figures. Plate V.

Figure 1*a*. A nearly perfect cup of this species.

" 1*b*. The base, shewing the small basal plates, with the quadrangular first primary radials between them.

" 1*c*, 1*d*, 1*e*, and 1*f*. Fragments of the column.

" 1*g*. The base of the column.

Locality and formation.—Trenton limestone, City of Ottawa.

Cleiocrinus grandis, Billings.

Plate V. Figures 2*a*–2*c*.

Description.—The column of this species is large, obscurely pentagonal, and composed of thin joints, every alternate one of which is about one fourth of a line wider than the one on each side of it. In consequence of this inequality in the size of the joints the column is closely annulated with slightly projecting rings, from six to eight in three lines. When perfect it is rounded-pentagonal, but when crushed it divides into five longitudinal lobes, as represented in figure 2*b*. Each joint appears to be composed of five pieces, and the articulating surfaces are striated with numerous fine, curved, radiating ridges. The radix or base of attachment of the column consists of a number of large roots, which appear to be composed of small polygonal plates. The alimentary canal is very large and nearly circular.

These columns have so nearly the structure of those of *C. regius*, that I have no doubt they belong to a species of that genus.

Explanation of Figures. Plate V.

Figure 2*a*. Portions of two individuals of this species, which appear to have grown upon the same spot.
" 2*b*. Fragment of a column, crushed.
" 2*c*. Transverse section, shewing the large alimentary canal.

Locality and formation.—Trenton limestone, Ottawa.

Cleiocrinus magnificus, Billings.

Plate V. Figure 3.

Description.—In this species the column is nearly round and composed of thin joints, of which there are from six to eight in two lines. The alimentary canal is pentagonal, and six lines in diameter where the column is nine lines. The cup has never been seen, but the size and form of the fragments of the stalk are sufficient to distinguish this species from any other in the Trenton limestone. It appears to belong to the genus *Cleiocrinus*. Diameter of column, from nine lines to one inch.

Locality and formation.—Trenton limestone, City of Ottawa.

Genus GLYPTOCRINUS, Hall.

(GLYPTOCRINUS, Hall, *Palæontology of New York*, volume i., page 280.)

FORMULA:

Basal plates, 5.	|	Regular inter-radials, 6.
Radial plates, 3×5.	|	Azygos inter-radials, 7 or more.

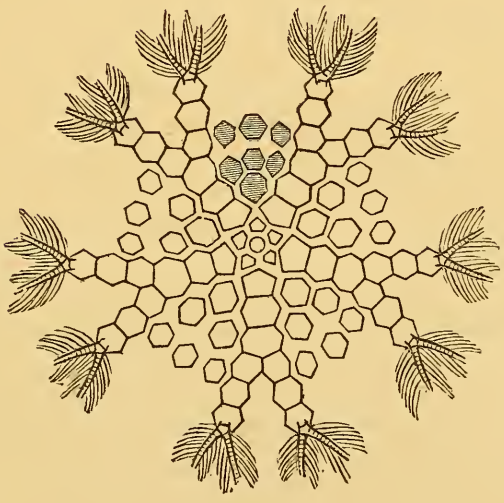

Fig. 18.

Figure 18. Diagram of the structure of the cup in the genus *Glyptocrinus*.

Generic characters.—Cup, pyriform, globular or oval, in some species very large; arms, long, densely fringed with pinnulæ; base, composed of five plates, which are either pentagonal or hexagonal; regular inter-radials, usually six; azygos inter-radials, seven or more; column, round or sub-pentagonal, strongly annulated or moniliform in all the species known.

The plates of the species of this genus are flat, thin, and either smooth or ornamented with radiating ridges, striæ or raised margins; the large joints of the columns are often nodulose. In the Black River and Trenton limestones in Canada, the remains of several species are exceedingly abundant, but usually reduced to mere fragments of the plates and column. At the city of Ottawa, where these

rocks are exposed on a large scale, three of the species hereinafter described, *G. priscus*, *G. ramulosus*, and *G. marginatus*, appear to be more common than at any other locality yet examined. The heads are frequently found there in a fragmentary state, but good specimens are rare. *G. priscus* is the only head collected in the Black River limestone, but it also occurs in the Trenton. I have met with *G. lacunosus* near the top of the Trenton limestone only. *G. ornatus* is found about the middle of the deposit, rather common, and in fewer numbers upwards to the Utica slate. There is a sixth species which also occurs at Ottawa, but is only known by its very characteristic sub-pentagonal column.

Glyptocrinus priscus, Billings.

Plate VII. Figures 1*a*–1*f*.

(G. priscus, *Report Geological Survey of Canada*, 1856, page 287.)

Description.—The cup of this species is pretty regularly oval, covered with smooth plates and surmounted by ten long undivided fingers or free rays, which are densely fringed with two rows of pinnulæ. A strong rounded carina, or ridge, runs up each of the primary rays, and, dividing into two upon the centre of the third plate, sends a branch up each of the secondary rays to the base of the fingers; the carinæ are also divided upon each of the basal plates, and coalesce into one on the centres of the first primary radial plates; in the azygos inter-radius a sixth ridge ascends to the top of the cup, dividing the space into two parts about equal; it bifurcates below on the centre of the large azygos, one branch proceeding to the centre of each of the two contiguous first primary radial plates. The basal plates are of a moderate size, but the first radials are large, broad, and in contact with each other by their upright lateral margins. The joints of the free rays are thin and very closely set. The rays are also rather broadly rounded on the back. As to the column, the only perfect head in the collection has but a single joint attached to its base, but the columns found associated with it and also those which have been observed in the Trenton limestone at Ottawa, along with the fragments of the heads of individuals of this species, are round, with the large joints rather thick and rather nodulose. I think this species grew to a very large size; but the evidence is not sufficient to connect positively the small specimen

examined with the large ten-fingered fragments found in the Trenton limestone.

EXPLANATION OF FIGURES. PLATE VII.

Figure 1*a*. View of the posterior side of *G. priscus*.
" 1*b*. Anterior side of the same specimen.
" 1*c*., 1*d*., 1*e*., 1*f*. Columns found associated with 1*a*.

Locality and formation.—One small perfect head collected at the upper mouth of the cave at the fourth chute of the Bonnechère, in the County of Renfrew, in the Black River limestone. Fragments of the heads and columns apparently referable to this species are common in the Trenton limestone at Ottawa.

GLYPTOCRINUS RAMULOSUS, Billings.

(G. RAMULOSUS, *Report Geological Survey of Canada*, 1856, page 258.)

Description.—The cup of this species very much resembles that of *G. priscus*. It is covered with smooth plates, and the primary and secondary rays are strongly keeled, but the base is broader, the basal plates smaller in proportion to the size of the body, and there are twenty free arms springing from the margin instead of ten, as in *G. priscus*. The arms also are several times bifurcated at various distances from the top of the cup, while those of the former species remain single to their extremities; the pinnulæ are in two rows, and from one-fourth to three-fourths of an inch in length; the ossicula of the arms are very thin, and interlock with each other so deeply that each seems to extend completely across, giving the appearance of but a single series of joints where in fact there are two. Near the base of the arms there are two joints in about one line, but higher up there are from four to eight in the same length. The arms are regularly rounded on the back, and comparatively slender, being scarcely more than one line in diameter at the base of the largest specimens. In the specimens examined four of the plates of each of the secondary rays are included in the general test of the body. The column is round, and at the base of the cup the large projecting joints are thin, sharp-edged, and crowded close together; they gradually become farther apart as the distance from the base of the cup increases, until at length they are from one to three lines removed from each other. Between these large joints the column is composed of very thin plates with crenulated margins, the projecting teeth of

one plate fitting into the corresponding notches of those in contact with it above and below. The edges of the large joints are nodulose, and the column is much larger at the base of the cup than at its lower extremity. One specimen tapers from one-fourth of an inch to one-eighth in a length of fifteen inches.

The form of the alimentary canal appears to vary in different parts of the same column, being usually more or less star-shaped, but sometimes circular. The separate large joints are generally seen in the shape of flattened rings, with the outside margin thick and rounded, but thinned down to a sharp edge around the perforation of the centre.

The columns of this species very much resemble those of *Schizocrinus nodosus* (Hall, Palæontology of New York, vol. i., pl. 10), and were always so called in Canada, until a number of specimens were found with the heads attached. The figures and description of that species however given by Professor Hall, show that it had four plates in the primary rays, and must be therefore not only specifically but generically distinct from *G. ramulosus*. I think that a large proportion of those great columns so common in the Trenton limestone on the Ottawa should be referred to this species and to *G. priscus*. Specimens four or five feet in length are sometimes seen in the quarries, and some of the crushed heads, including the arms, are seven inches in length.

A highly interesting specimen in the cabinet of Dr. Van Cortlandt of the city of Ottawa, consists of the inside of a cup two inches and a half in length and one inch and seven-eighths in diameter, at the base of the free arms. It had been completely embedded in the stone, but by some means the body has been extracted, leaving all the plates lining the cavity in their natural position. Each of the plates has a small tubercle in its centre, on the inside. The impression of a fragment of the column one inch and a half in length from the base of the cup downwards still remains. The characters of the column are precisely those of many of the large ones usually seen without the heads attached. If therefore any of these large columns belong to this species, then in their advanced age they must have lost their nodulose character, because they are smooth instead of nodose, as is the case with the smaller specimens in the collection of the Survey which have the heads attached. It appears to me that in all the species of *Glyptocrinus* the columns were ornamented until past the middle age, and that afterwards they became plain.

EXPLANATION OF FIGURES. PLATES VII. AND VIII.

Plate 7, figure 2*a*. A cup of medium size.
" 2*b*. Portion of the column near the base of the cup.
" 2*c*–2*f*. These figures represent different parts of a very long column.
Plate 8, figure 1*a*. A crushed specimen, with part of the column attached.
" 1*b*. The column of 1*a*, enlarged.
" 1*c*, 1*d*. Columns found along with 1*a*.

Locality and formation.—Trenton limestone, City of Ottawa, Island of St. Joseph, in Lake Huron.

GLYPTOCRINUS MARGINATUS, Billings.

Plate IX. Figure 1*a*.

(G. MARGINATUS, *Report Geological Survey of Canada*, 1856, page 260.)

Description.—The plates of this fine species are all margined by a strong elevated border, the effect of which is to give to the surface a beautifully reticulated appearance. The only specimen in the collection is crushed, but then the size of the plates near the bottom shows that it had a broad, rounded base, and that its general form was sub-globular. The azygos inter-radial space contains ten plates below the level of the base of the secondary rays; the rays are all carinated, and there is also an upright row of small plates (in the centre of the azygos inter-radial space) which exhibits a faint keel. There are four or five of the secondary radial plates included in the cup. A piece of the column two inches and a half in length remains attached, and shows that the large joints at the base of the cup of this species were much thicker, and consequently not so sharp-edged as those occupying a similar position in the other species.

The length of this cup from the base to the free arms is one inch and a half, and the breadth about the same. The column is four lines in diameter, and in the length of two inches and a half there are twenty-one large joints with the same number of others a little smaller, each situated half way between two of the largest. The arms are not preserved in the specimen.

This species also grew to a large size, and was closely related to both *G. priscus* and *G. ramulosus*.

EXPLANATION OF FIGURES. PLATE IX.

Figure 1*a*. View of the only specimen collected.

Locality and formation.—Trenton limestone, City of Ottawa.

Glyptocrinus ornatus, Billings.

Plate IX. Figure 2*a*.

(G. ornatus, *Report Geological Survey of Canada*, 1856, page 260.)

Description.—In the specimens of this species that have been collected the cup is broad-oval, the base well rounded, but narrower than the upper extremity; the rays (as in the other species) are keeled, and there are ten long, slender, undivided free arms, as in *G. priscus*. Each of the plates is ornamented with five or six sharp ridges, which radiate from the centre, thus covering the body with numerous stars with triangular interspaces. The column is round, and the large joints are thin, sharp-edged, and distant from each other half a line at and near the base of the cup in a specimen of the ordinary size.

Length of the cup in several specimens, a little more than half an inch; diameter at the base of the free rays, about the same; diameter of column at the base of the cup, about one line.

The surface ornament of this species is very like that of *G. decadactylus* (Hall) of the Hudson River group; but there is a very decided difference in the form of the columns of the two. Those figured by Professor Hall have the large joints very thick and rounded, while in *G. ornatus* they are exceedingly thin and sharp-edged; some of our specimens are very like the figure of *G. basalis* (McCoy), given on page 180 of Sir Roderick Murchison's Siluria, 1st edition. In Sedgwick and McCoy's British Palæozoic Rocks, (p. 57) however, that species is described by Prof. McCoy as having the pelvic plate immediately below the large inter-radial space, hexagonal, and supporting upon its upper truncated margin the large inter-radial. In our species all the pelvic plates are very small and pentagonal. To both the English and New York species ours is evidently closely allied.

Explanation of Figures. Plate IX.

Figure 2*a*. Anterior side of a specimen of *G. ornatus*.

Locality and formation.—Upper half of the Trenton limestone, City of Ottawa.

Glyptocrinus lacunosus.

Plate VIII. Figures 3*a*–3*e*.

(G. lacunosus, *Report Geological Survey of Canada*, 1856, page 261.)

Description.—This species is characterized by its very large basal plates, one of which, that beneath the azygos inter-radial space, is hexagonal, and supports upon its upper truncated edge the first azygos inter-radial. The surface of the body is completely covered with small rugose pits and wrinkles; the rays become free at the second or third secondary radial plate; they divide immediately after becoming free, at least once, perhaps again above, but the specimens do not shew them perfectly above the first sub-division. The body is sub-globular, about three-quarters of an inch in length, and the same in breadth.

The column is round, and when once carefully examined is easily distinguished from that of any other species occurring in the Trenton limestones. The large joints are proportionally very broad and projecting, while the constrictions between them are wide and deep. At the distance of from six to ten inches from the base of the cup the large joints disappear altogether, and the column becomes smooth, like that of the genus *Rhodocrinus*. In one specimen, at the distance of three inches from the base of the cup, the large joints are nearly one line in thickness at their edges, and are two lines distant from each other; they are also two and a half lines in diameter; the constricted portion of the column between them is scarcely one line.

Explanation of Figures. Plate VIII.

Figure 3*a*. A specimen with part of the column attached.
" 3*b*. Fragment of a different specimen.
" 3*c*, 3*d*, 3*e*. Columns of this species.

Locality and formation.—Upper half of the Trenton limestone, City of Ottawa.

Rhodocrinus pyriformis, Billings.

Plate VI. Figures 1*a*–1*d*.

(Thysanocrinus [Rhodocrinus] pyriformis, *Report Geol. Survey of Canada*, 1856, p. 263.)

Description.—Cup, conical or pyriform, the adult specimens about two inches in length and one inch and a half in their greatest

diameter, which is near the base of the free rays. The basal plates are pentagonal, with an obscurely-rounded ridge across their base; sub-radials, hexagonal, each supporting upon its truncated upper margin a large inter-radial. The first primary radial on each side of the azygos inter-radial space is hexagonal, the other three are pentagonal; the second plates in the rays are hexagonal, and the third heptagonal; each of the latter supporting upon its upper sloping edges the bases of two secondary rays, which become free at the third or fourth plate, thus furnishing ten arms, which divide at not quite one-fourth of an inch from their base, and again at half an inch; the full grown arms are again subdivided, some of them once, others twice. The arms are comparatively short, not exceeding two inches in length in a specimen whose cup measures one inch and a half in length. The ossicula which constitute the double series of joints of the free rays or arms, are obtusely cuneiform, the two rows interlocking with each other so slightly that the points of the joints extend but a short distance across the centre of the back of the arm; there are two ossicula to one line in length in that portion of the arm at the base which is situated next the cup, and below the first sub-division; the arm here is scarcely one line in thickness. All the plates are smooth or slightly granulated on their surface; in some of the specimens there is a trace of an obscurely-elevated margin round the plates, and there is also a broadly-rounded keel, not very prominent, upon each of the primary and secondary rays.

The column is round, slender, annulated, with thin but round-edged projecting joints, for several inches below the bottom of the cup; it then becomes smooth, and continues of an uniform size to the base of attachment, which consists of a number of root-like branches. The annulated portion of the column is usually found a little curved, but the smooth, cylindrical portion is always straight, and in this part there are about ten joints to two lines of the length; near the cup there are three or four annulations to two lines. The diameter of the column is from one and a half to two lines and a half, and the length varies greatly; one specimen, a very perfect impression of the head, column and root, all in their natural connection, measured but seventeen inches in length; a fragment of the smooth portion of a column still lying in the rock measures thirty-seven inches and a half. At Ottawa, in the upper part of the Trenton limestone, there are fragments of smooth, round columns, four or five lines in diameter, which appear to be a large variety of this species.

EXPLANATION OF FIGURES. PLATE VI.

Figure 1*a*. A specimen with part of the column attached.
" 1*b*, 1*c*. Crushed specimens.
" 1*d*. The radix of this species.

Locality and formation.—Trenton limestone, City of Ottawa, plentiful ; also in the upper part of the same formation, around the base of the mountain at Montreal, where the columns are rather common.

RHODOCRINUS MICROBASALIS, Billings.

Plate VI. Figure 2.

(THYSANOCRINUS [RHODOCRINUS] MICROBASALIS, *Rep. Geol. Survey of Canada*, 1856, p. 264.)

Description.—The specimens for which the above specific name is proposed are about five-eighths of an inch in height, and the same or a little more in breadth at the top. They are cup-shaped, and uniformly expanding from the narrow base upwards. The basal plates are so small that they can only be well seen when the column is removed. The rays are keeled, and all the plates of the body exhibit obscure, radiating ridges, somewhat similar to those of *Glyptocrinus ornatus*, but not so prominent. The column is round, annulated in its upper and smooth in its lower part. I have not seen either the root or the arms.

This species is closely allied to *R. pyriformis*, but differs in its much smaller size, in the comparative minuteness of the pelvic plates, and also in the character of the surface. *R. pyriformis* is a large, smooth species, but this one has a surface ornamented with stars, only well seen however on good specimens.

Locality and formation.—Trenton limestone, City of Ottawa.

Genus RETEOCRINUS, Billings.

Generic characters.—This remarkable genus has no perfectly formed plates. The cup consists of a reticulated skeleton, composed of rudimentary plates, each consisting of a central nucleus, from which radiate from three to five stout processes. Of such plates there are five in the basal series, five in the sub-radial, and five in the radial series. On the azygos side the sub-radial has five processes; the others have four each.

The principal difference between this genus and such genera as *Dendrocrinus*, *Porocrinus*, *Palæocrinus*, and *Cyathocrinus*, consists in the incompleteness or rudimentary character of its plates. The arrangement of the parts of the skeleton is the same.

Reteocrinus stellaris, Billings.

Plate IX. Figures 4*a*–4*e*.

Description.—The cup of this species appears to be about five lines in height and six lines in width. The projecting processes of the plates, and also the joints of the arms to first bifurcation, are rounded on the outside, and half a line in thickness. The first joint of the right anterior ray (which is the first primary radial,) has three processes, the upper one of which supports an arm, while the two lower rest, one of them on one of the upper processes of the azygos sub-radial and the other upon a process of the right anterior sub-radial. It is probable that the other rays are constructed and situated in nearly the same manner. The azygos sub-radial has five processes, three above and two below. The central of the three upper processes supports an upright series of joints (as represented in figure 4*a*, plate 9). If this series of joints constitute a true arm, then there must be six arms in this species. The right arm divides above the fourth joint; I have not seen the other arms distinctly. The spaces between the arms are occupied by numerous small stellate plates, which may have belonged either to an integument connecting the arms, or to the covering of the abdomen. The column is round, and composed of very thin plates near the base of the cup. At the distance of about one inch and a half below the base of the cup the joints alternate in thickness.

None of the specimens collected are perfect, and the characters of the species therefore have not been fully ascertained.

Explanation of Figures. Plate IX.

Figure 4*a*. View of the anterior side of a specimen.

" 4*b*. A specimen retaining a piece of the column; 4*c*, several of the joints enlarged. They appear to be nearly equal in size, and sharp-edged at the base of the cup.

" 4*d*, 4*e*. Fragments of this species.

[In 4*a* and 4*e* the small stellate plates between the arms are represented.]

Locality and formation.—Trenton limestone, City of Ottawa.

Reteocrinus? fimbriatus, Billings.

Plate IX. Figures 3*a*–3*c*.

Description.—Length of the only specimen discovered, including the arms, about fifteen lines; basal plates, minute; sub-radials, one line in height; arms, several times divided and furnished with pinnulæ. At the apex of each of the basal plates there is an aperture half a line in width, and another of the same size at the lower angle of each first primary radial. The primary rays, so far as they have been observed, consist each of three plates, the first heptagonal, the second hexagonal, and the third pentagonal,—the spaces between them filled with very small plates. A single joint of the column remains attached to the base of the cup. It is pentagonal, with slightly concave faces and rather sharp angles.

The specimen is very imperfect, and it is with much doubt that I refer it to the genus *Reteocrinus*.

Explanation of Figures. Plate IX.

Figure 3*a*. The only specimen discovered.
" 3*b*. The base, enlarged; the unshaded pentagonal space shews the form of the upper joint of the column.
" 3*c*. One of the arms, with some of the pinnulæ attached, enlarged.

Locality and formation.—Hudson River group, Charleton Point, Anticosti.

Syringocrinus paradoxicus, Billings.

Plate X. Figure 14.

Description.—Of this crinoid no perfect specimens have been collected. The fragment figured exhibits in the side exposed two series of polygonal plates, so arranged that they appear to constitute part of a tube, one half of which (probably composed of two other series of plates,) is buried in the stone. At one extremity (the lower end in the figure,) this tube is one line and and a half in diameter; but as it appears to be flattened by pressure, its thickness did not probably much exceed one line when not distorted. At the other end it seems to be somewhat larger, but this may be owing to the separation of the plates. At this extremity also there appears to be

attached to the main body of the tube an additional part, composed of numerous small, elongated, irregular plates, placed transversely.

That this curious fossil is part of a crinoid, I have not the least doubt; and further, it seems quite certain that it does not belong to any known genus. The above generic and specific names are proposed for it provisionally.

Locality and formation.—Trenton limestone, Beauport, near Quebec.

Genus COMATULA.

Memoir on the Star-Fish of the genus Comatula, demonstrative of the Pentacrinus europæus being the young of our indigenous species. By JOHN V. THOMPSON, F.L.S., Deputy Inspector-General of Hospitals. Communicated by Sir James M'Grigor, F.R.S. *

[Extracted from *Jameson's Edinburgh New Philosophical Journal*, vol. xx., p. 295.]

"If we were told by any traveller that he had visited an unknown region, where the animals dropt their eggs on trees and shrubs, which there fixed themselves and shot up like parasitic plants on a long stem, gradually evolving, at their extreme end, member after member and function after function, until the young animals became so perfect as to resemble their parents in every essential point,—when their attachment to the connecting foot-stalk was dissolved, and they became free and locomotive, and betook themselves to the wandering life of the parent stock! few could be got to believe facts so incredible, and so much at variance with the course of nature, as made manifest everywhere and from all time; but if established on incontestable evidence, the highest degree of surprise and admiration would necessarily supplant our incredulity,—voyages would be undertaken, and the curious of every country would flock to witness such an extraordinary anomaly, at the greatest risk and expense. If, then, a fact so contrary to our experience relating to the superior classes of animals should be capable of exciting so great a degree of interest, it may be presumed that an analogous circumstance, now for the first time actually discovered in an animal belonging to one of the inferior classes, must be considered at least as highly worthy of the attention of the philosophic naturalist.

"It is no uncommon thing, in the inferior classes of the animal kingdom, to find animals permanently attached from the period of their birth, and during the whole time of their existence, familiar examples of which we have in the oyster, anomia, and various other

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* Read before the Royal Society of London, in June, 1835.

bivalve shell-fish, and in numerous compound animals of the classes Zoophyta and Infusoria. I have also shewn, in my memoirs on the Cirripedes, examples of animals being free and locomotive in their first stages, and afterwards becoming permanently fixed; but an animal growing for a period as it were a flower, fixed by its stem, and then dropping from its pedicle and becoming, during the remainder of its life, free and locomotive, is not only new, but without any parallel in the whole range of the organized part of the creation. No wonder, then, that any naturalist, on the first discovery of the young animal in its first or fixed stage of existence, should consider it as belonging exclusively to those which are known to be permanently fixed; analogy would permit no other conclusion to be formed, and consequently it could be classed with none other except the Crinoideæ, one known genus of which tribe participates with *Comatula* in being locomotive in its advanced stage; so that this circumstance connects all these animals into an inseparable group, with which the present state of our knowledge will not permit us to associate any other of the Asteriæ.

Fig. 19.

Figure 19. Adult *Comatula decanemos.*

"When, therefore, I formerly described the young of the *Comatula** as a new species of *Pentacrinus*, no person could have suspected so anomalous and unexpected a result, as that it was the young state of this curious star-fish, an animal not only free, but leading the most vagrant life of any of the tribe with which it has hitherto been associated by naturalists,—at one time crawling about amongst submarine plants, at others floating to and fro, adhering to thin fragments by means of its dorsal claspers, or even swimming about after the

* Memoir on *Pentacrinus europæus.* Cork, 1827.

manner of the *Medusæ*. In swimming, the movements of the arms of the *Comatulæ* exactly resemble the alternating strokes given by the *Medusæ* to the liquid element, and have the same effect, causing the animal to raise itself from the bottom, and to advance, back foremost, even more rapidly than the *Medusa*. Fig. 19 represents a *Comatula*, after having delivered its stroke to the water.

"The evidence of *Pentacrinus* being the young of *Comatula*, rests upon a comparison of the individuals figured,—20, 21, and 22, 23,—the former being an advanced *Pentacrinus* just beginning to form pinnæ, and the latter the youngest *Comatula* ever taken by dredging. In the *Pentacrinus*, it is to be observed that the arms are just beginning to form pinnæ towards their extremities, that they have the sulphur-yellow color and dark marginal spotting observable in the other, which shews, in like manner, that the upper pinnæ are first formed; here, figs. 22, 23, we have about three pairs of pinnæ, with two intervening articulations of the arm between each, then three articuli (counting from the apex downwards), and an additional pair of pinnæ just beginning to sprout. From this to the base of the arm are five more articuli, as yet without any pinnæ, the base of each arm on either side presenting one long pinna appropriated to the service of the mouth. On turning the animal over, the dorsal cirri are found to have increased from five to nine, several of them presenting the appearance of recent formation. Individuals a little older are comparatively common, in which the pinnæ are complete, and from this period they appear to form regularly at the apex of the arm, as this goes on extending in length. These small *Comatulæ* still retain the original sulphur-yellow color towards the apices of the arms, the lower part and body assuming the characteristic red of the adult *Comatula*. From observations repeatedly made, I think it most probable that the Comatulæ attain their full growth in one year, so as to be in a condition to propagate their kind the summer following that of their birth. At that time (viz., May and June,) these full grown individuals have the membranous expansion inside each of the pinnæ considerably extended, at least as far as the fifteenth or twentieth pair; these, which are the matrices or conceptacula, at length shew themselves distended with the ova, which in July, and even earlier, make their exit through a round aperture on the fascial side of each conceptaculum, still, however, adhering together in a roundish cluster of about a hundred each, by means of the extension and connection of their umbilical cords. By what means these ova are dispersed, or how they become attached to the stems and branches of corallines, remains

to be discovered; but it is strongly to be suspected that the animal is gifted with the power of placing them in appropriate situations, otherwise we should find them indiscriminately on fuci, shells, stones, etc., which does not appear to be the case. However this may be, if we are allowed to assume that the *Pentacrinus europæus* is the young of *Comatula*, we first perceive the dispersed and attached ova in the form of a flattened oval disk, by which it is permanently fixed to the spot selected, giving exit to an obscurely-jointed stem, ending in a club-shaped head, as in fig. 25, *e*, in which individual the animal is sufficiently advanced to shew the incipient formation of the arms and the mouth with its tentacula, by means of which it obtains the food

Fig. 22.

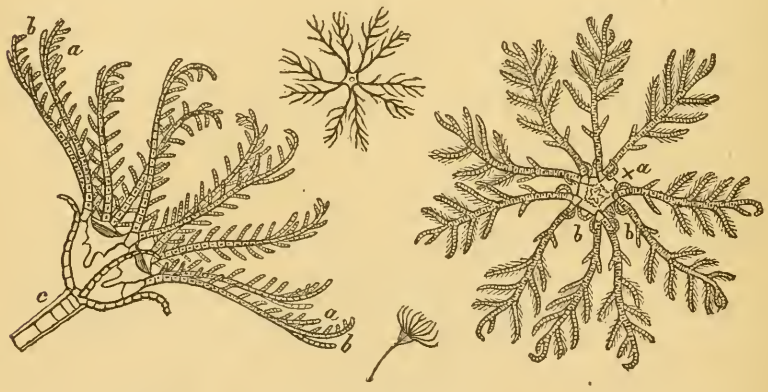


Fig. 21. Fig. 20. Fig. 23.

Figures 20 and 21. An individual of the natural size, and magnified, still more developed than 25, *e*, beginning to form pinnæ towards the ends of the arms, as at *a*, *b*; in this the cirri or claspers at the back of the animal are very distinctly seen.

Figures 22 and 23. A very young *Comatula* of the natural size, and magnified; ×*a*, the vent, in front is the star-like mouth; *b*, *b*, two of the dorsal cirri.

necessary to its successive growth. At *d* of the same figure is another, somewhat more advanced, in which all the ossicula of the arms are obvious, as far as the bifurcation. At the letters *a*, *b*, and *c*, are represented what I considered formerly as completely formed *Pentacrini*, (*a*) from the position shewing the valvular mouth, and (×) the anal aperture: (*b*) shews most clearly the cirri or claspers at the top of the stem, and (*c*) that the living principle extend throughout the entire fabric demonstrated by the varied *movements* of the pedicle. At a later period I observed individuals shewing a still higher degree of

development, figure 21, and in which the arms had the appearance of bifurcating twice towards their extreme ends, and had become of a sulphur-yellow color, with a zone of dark colored spots along either margin.

"Another circumstance confirmatory of these being the young of *Comatula* is derived from these *Pentacrini* being first seen about the time of the dispersion of the ova of the *Comatulæ*, and again entirely disappearing in September, the only season when young *Comatulæ* are to be obtained, and such as are represented in figs. 22, 23. In these

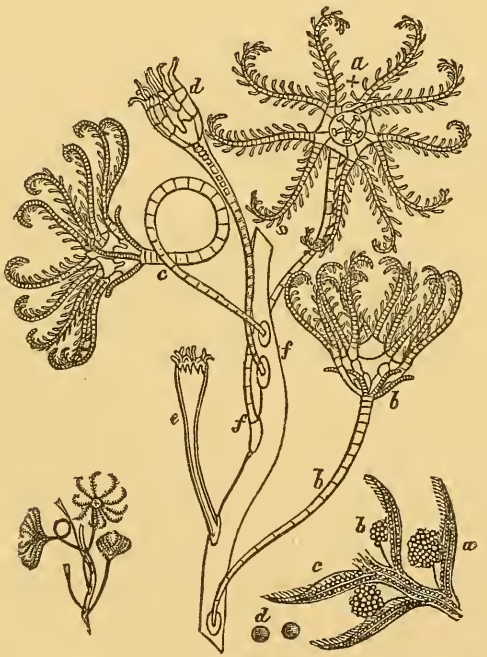


Fig. 24. Fig. 25. Fig. 26.

Figure 24. *Pentacrinus europæus.* A group, natural size.

" 25. The same, magnified; *f*, the basis; *e* and *d*, two individuals in early stages of growth; *a*, *b*, *c*, fully developed individuals; at +, letter *a*, the anus is seen, and below it the mouth of the animal.

" 26. Part of one of the arms seen in face; *a*, ova protruding from the conceptacula; *b*, ova just beginning to make their exit; *c*, one as yet filled with the ova; *d*, ova magnified.

the points of resemblance to advanced *Pentacrini* have been already alluded to, and it is quite evident, that since they became detached, pinnæ must have been added in both directions, both towards the

apex and downwards towards the base of the arms. These specimens which have made a further progress are plentiful, and have all the pinnæ complete down to the bifurcation, with a few additional claspers added at the back. At figure 19, a middle-sized *Comatula decanemos* is given, as they appear in June when pregnant with ova; and at fig. 26 is a portion of an arm magnified, with the ova beginning to escape from the conceptacula, which they do successively from the base upwards. Mr. Millar, in his labored but excellent work on the Crinoideæ, has figured our *Comatula* in this stage as a new species, under the title of *C. fimbriata;* indeed, no naturalist who had not investigated their habitudes in their own element, and at all seasons, could possibly arrive at the knowledge of this very remarkable and curious piece of economy, which may be considered as unique. These animals are further distinguished by the peculiarity of having two openings to the intestinal canal, by which they also differ from the rest of the Asteriæ.

"The great abundance of *Comatulæ*, in the places they inhabit, is not to be wondered at when we are aware how exceedingly prolific they are; thus each arm may be estimated to bear thirty fruitful conceptacles, each producing about a hundred ova, and as there are ten such, this gives 30,000! as the amount of ova produced by a single individual."

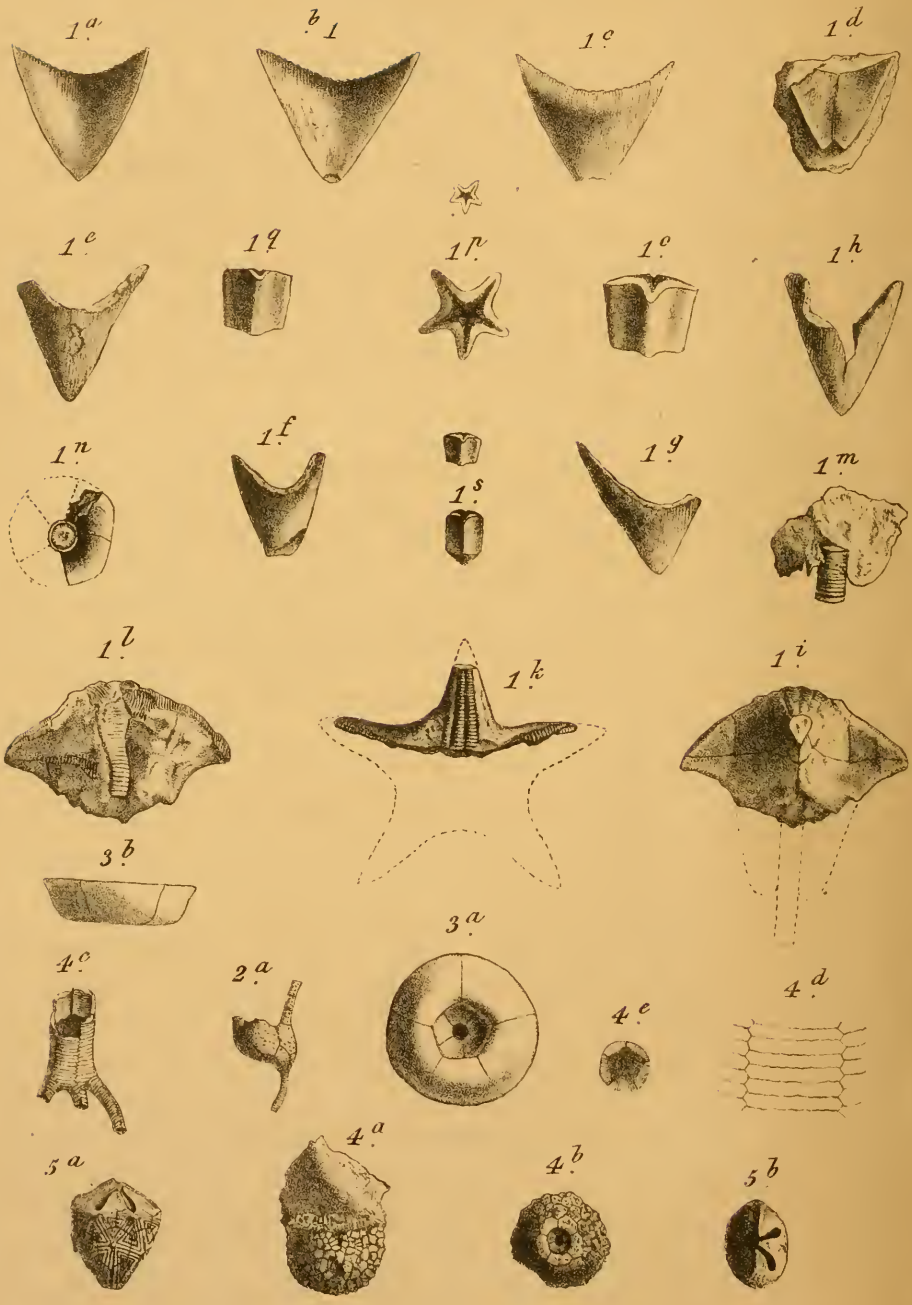

1.a
1.b
1.c
1.d
1.e
1.q
1.p
1.o
1.h
1.n
1.f
1.s
1.g
1.m
1.l
1.k
1.i
3.b
3.a
4.c
2.a
4.e
4.d
5.a
4.a
4.b
5.b

PLATE I.

Blastoidocrinus carchariædens (page 18).

Figure 1*a*–1*h*. Deltoid plates of *B. carchariædens.*

" 1*i*. Side view of a specimen which has three of the rays partly preserved.

" 1*k*. The same, seen from above.

" 1*l*. Vertical section, shewing the position of the column in the interior.

" 1*m*. Fragment of the base, shewing the manner in which the column penetrates into the visceral cavity.

" 1*n*. Under side of 1*m*.

" 1*o*–1*s*. Small pentagonal crinoidal remains found associated with *B. carchariædens.*

Hybocrinus pristinus (page 23).

Figure 2*a*. Left side of a specimen which retains a portion of the column and part of one of the arms.

Pachyocrinus crassibasalis (page 22).

Figure 3*a*. View of the base of the only specimen collected.

" 3*b*. Side view of the same.

Rhodocrinus asperatus (page 27).

Figure 4*a*. Side view of a specimen.

" 4*b*. View of the base.

" 4*c*. A radix found in the same slab along with 4*a*.

" 4*d*. Portion of the surface of 4*c*, magnified. The joints of this column appear to be composed near the root of five pieces each, which interlock, as represented in the figure 4*d*.

" 4*e*. Transverse section of the column near the root.

Palæocrinus striatus (page 25).

Figure 5*a*. Posterior side of a nearly perfect specimen.

" 5*b*. Summit of the same, shewing the ambulacral orifices and grooves.

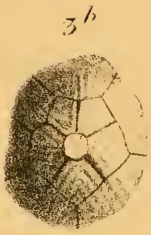
1c

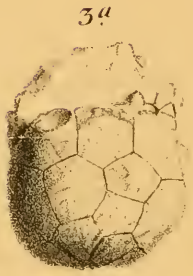
1b

1a

1c

1d


3b


3a

3c

3d

4.

5c

2b

5a

5b

3e

2a

5d

PLATE II.

HYBOCRINUS TUMIDUS (page 28).

Figure 1*a*. View of the anterior side of a specimen, shewing the azygos plates.

" 1*b*–1*d*. Different views of other specimens.

" 1*e*. A polished transverse section just below the base of the arms, shewing the channels in the primary radial plates for the ambulacral orifices.

HYBOCRINUS CONICUS (page 29).

Figure 2*a*. Right side of a specimen of the average size.

" 2*b*. Left side of another specimen.

CARABOCRINUS RADIATUS (page 31).

Figure 3*a*. View of the anterior side, shewing the azygos inter-radius.

" 3*b*. Base of the same specimen.

" 3*c*. Posterior side of a different specimen.

" 3*d*. Ventral surface of a small individual. In the centre of the lower side of the figure is the mouth, and directly above it the small anal aperture.

" 3*e*. Ventral surface of a larger specimen, shewing obscurely the five ambulacral grooves. The three round darkly-shaded spots appear to be apertures accidentally produced.

CARABOCRINUS VANCORTLANDTI (page 32).

Figure 4 represents the posterior side of the specimen.

POROCRINUS CONICUS (page 34).

Figures 5*a*, 5*b*. Posterior views of two specimens.

" 5*c*. Anterior side of a specimen, enlarged to shew the azygos plates and poriferous areas.

" 5*d*. Ventral surface of 5*a*.

Horace Smith. Del.

G. Matthews. Montreal.

PLATE III.

Dendrocrinus gregarius (page 36).

Figure 1*a*. Posterior view of a specimen.
" 1*b*. The left side.
" 1*c*. Column, enlarged.

Dendrocrinus acutidactylus (page 37).

Figure 2*a*. Posterior side of a specimen.
" 2*b*. Portion of the column, enlarged.

Dendrocrinus proboscidiatus (page 38).

Figure 3*a*. Anterior side.
" 3*b*. Part of surface of proboscis, enlarged.
" 3*c*. Portion of column, enlarged.

Dendrocrinus humilis (page 39).

Figure 4. The only specimen discovered ; posterior side.

Dendrocrinus latibrachiatus (page 39).

Figure 5*a*. View of the left side, shewing the left anterior ray, which has the first and second primary radials included in the cup.
" 5*b*. View of the anterior side.
" 5*c*. The posterior side.

Palæocrinus angulatus (page 45).

Figure 6*a*. Left side of the only specimen discovered.
" 6*b*. Column, enlarged.

Dendrocrinus rusticus (page 41).

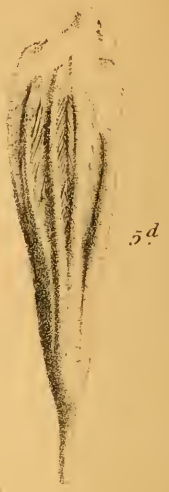
Figure 7*a*. A specimen very imperfect.
" 7*b*. A small portion of the column, enlarged.

Dendrocrinus cylindricus (page 44).

Figure 8*a*. Anterior side of *D. cylindricus*. That which appears to be a large arm near the left side is the proboscis.
" 8*b*. Part of the column, a little enlarged.

7a.

5a.


5d.

3a.

5c.

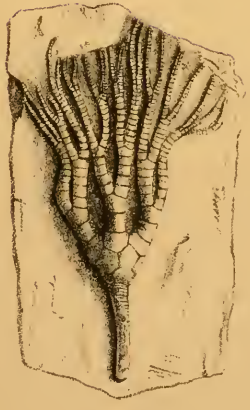
6a.

6b.

1a.

5b.

1b.


4a.

4b.

8.

2a.

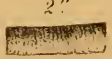

2b.

PLATE IV.

Dendrocrinus conjugans (page 41).

Figure 1*a*. Anterior side.
" 1*b*. Column, a little enlarged.
" 2*a*. Side view of a specimen.
" 2*b*. Column of same, enlarged.

Lecanocrinus lævis (page 47).

Figure 3*a*. A slightly crushed specimen.

Lecanocrinus elegans (page 47).

Figure 4*a*. A specimen shewing one of the hexagonal basal plates.
" 4*b*. Several joints of the column, a little enlarged.

Heterocrinus Canadensis (page 48).

Figure 5*a*. A specimen with part of the column attached.
" 5*b*. Portion of the column, enlarged.
" 5*c*. Anterior side of a different specimen.
" 5*d*. A specimen which has the pinnulæ preserved.

Heterocrinus tenuis (page 50).

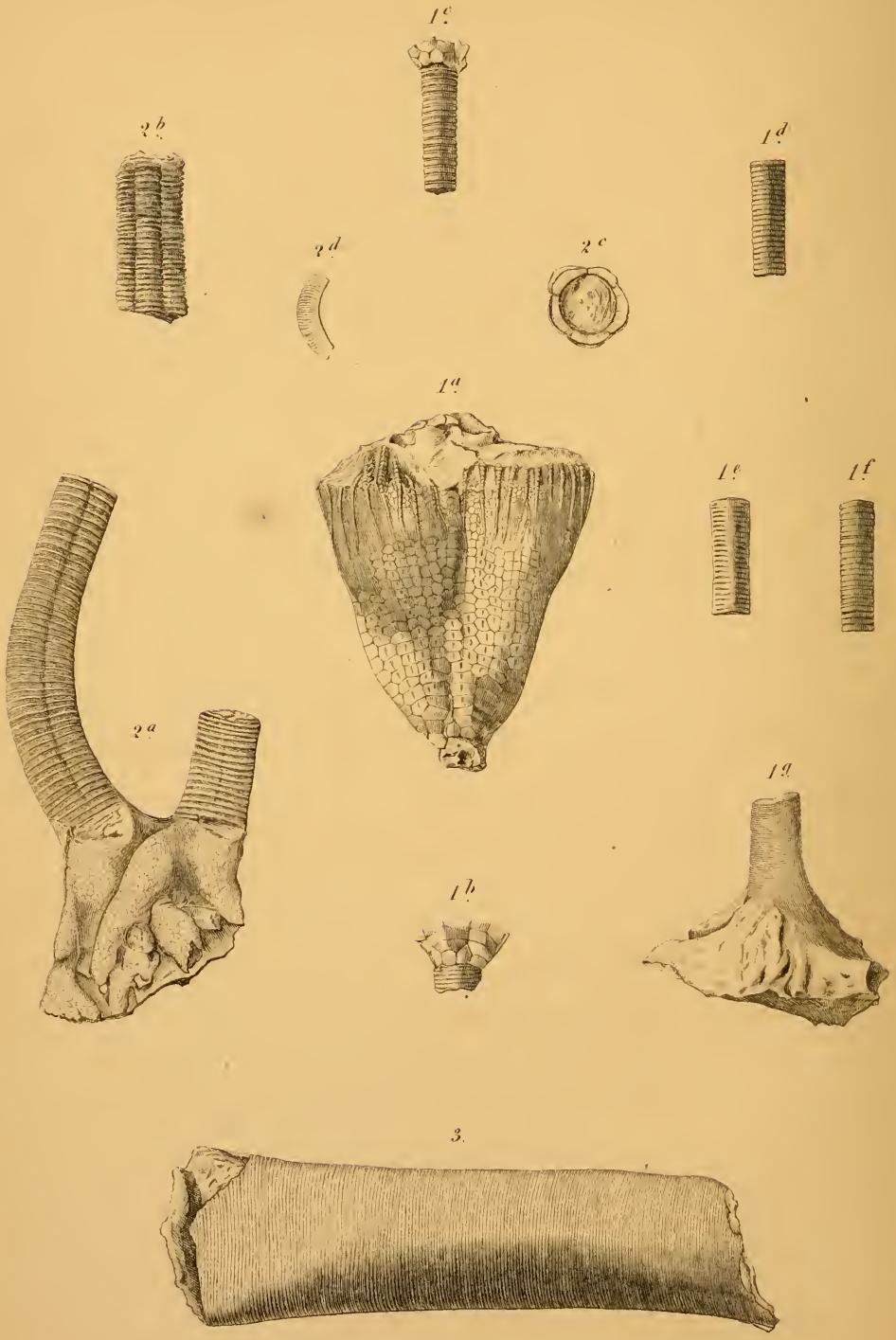
Figure 6*a*. A specimen with part of the column.
" 6*b*. A few joints of the column, enlarged.
[See also Plate X.]

Heterocrinus inæqualis (page 51).

Figure 7*a*. A nearly perfect specimen, but so deeply embedded in stone that only one side can be seen.

Heterocrinus articulosis (page 51).

Figure 8. One of the rays of this species.



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G. Matthews Montreal

PLATE V.

CLEIOCRINUS REGIUS (page 53).

Figure 1*a*. A nearly perfect cup of this species.

" 1*b*. The base, shewing the small basal plates, with the quadrangular first primary radials between them.

" 1*c*, 1*d*, 1*e*, and 1*f*. Fragments of the column.

" 1*g*. The base of the column.

CLEIOCRINUS GRANDIS (page 54).

Figure 2*a*. Portions of two individuals of this species, which appear to have grown upon the same spot.

" 2*b*. Fragment of a column, crushed.

" 2*c*. Transverse section, shewing the large alimentary canal.

[This species occurs also at Montreal, in the Trenton limestone.)

CLEIOCRINUS MAGNIFICUS (page 54).

Figure 3. Fragment of the column of this species.

1a.
2
1d
1b
1c
3.

PLATE VI.

Rhodocrinus pyriformis (page 61).

Figure 1*a*. A specimen with part of the column attached.

" 1*b*, 1*c*. Crushed specimens.

" 1*d*. The radix of this species.

Rhodocrinus microbasalis (page 63).

Figure 2. An imperfect specimen of this species.

Rhodocrinus gigas.

Figure 3 is a fragment of the column of a large *Rhodocrinus* which occurs in the upper part of the Trenton limestone, at the City of Ottawa. I have not seen the cup, but as the columns are easily recognizable, I propose the above name for them.

1.a

1.b

1.d

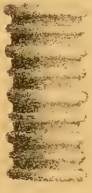
1.e

1.c

1.f

2.a

2.e



2.d

2.b

2.f

2.e

PLATE VII.

GLYPTOCRINUS PRISCUS (page 56).

Figure 1*a*. View of the posterior side of *G. priscus*.

" 1*b*. Anterior side of the same specimen.

" 1*c*, 1*d*, 1*e*, 1*f*. Columns found associated with 1*a*.

GLYPTOCRINUS RAMULOSUS (page 57).

Figure 2*a*. A cup of medium size.

" 2*b*. Portion of the column near the base of the cup.

" 2*c*–2*f*. These figures represent different parts of a very long column.

[See also Plate VIII.]

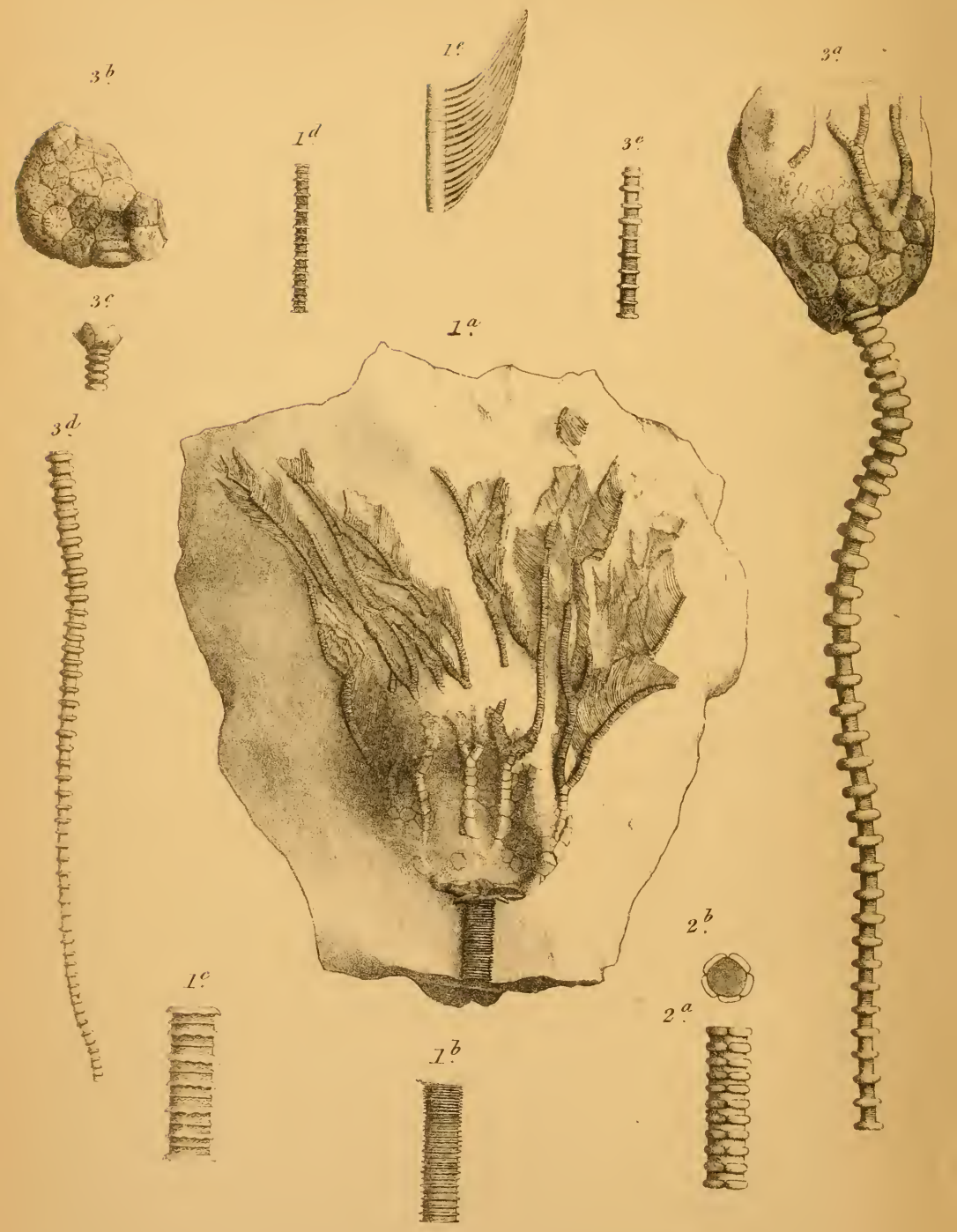

3b
1f
3a
1d
3e
3c
1a
3d
2b
1c
2a
1b

PLATE VIII.

GLYPTOCRINUS RAMULOSUS (page 57).

Figure 1*a*. A crushed specimen, with part of the column attached.

" 1*b*. The column of 1*a*, enlarged.

" 1*c*, 1*d*. Columns found along with 1*a*.

" 1*e*. A portion of one of the arms, enlarged.

[See also Plate VII.]

GLYPTOCRINUS LACUNOSUS (page 61).

Figure 3*a*. A specimen with part of the column attached.

" 3*b*. Fragment of a different specimen.

" 3*c*, 3*d*, 3*e*. Columns of this species.

GLYPTOCRINUS QUINQUEPARTITUS.

Figure 4*a*–4*b*. Columns such as the specimen represented by these figures are not uncommon in the upper part of the Trenton limestone, at the City of Ottawa.

4 d
3 a
4 a
1 a
3 c
4 c
3 b
4 b
2 a
4 c

PLATE IX.

Glyptocrinus marginatus (page 59).

Figure 1*a*. The only specimen collected. The part well exposed (represented in the right side of the figure) is the azygos inter-radius.

Glyptocrinus ornatus (page 60).

Figure 2*a*. Anterior side of a specimen of *G. ornatus*.

Reteocrinus fimbriatus (page 65).

Figure 3*a*. The only specimen discovered.

" 3*b*. The base, enlarged; the unshaded pentagonal space shews the form of the upper joint of the column.

" 3*c*. One of the arms, with some of the pinnulæ attached, enlarged.

Reteocrinus stellaris (page 64).

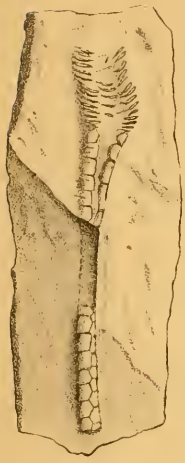
Figure 4*a*. View of the anterior side of a specimen.

" 4*b*. A specimen retaining a piece of the column.

" 4*c*. Several of the joints enlarged. They appear to be nearly equal in size, and sharp-edged at the base of the cup.

" 4*d*, 4*e*. Fragments of this species.

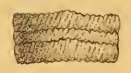
[In 4*a* and 4*e* the small stellate plates between the arms are represented.]


14.

2 c.

5.

4.

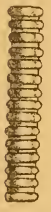

2 b.

1 a.

7.

6.

2 a.


9.

8.

1 d.

3.

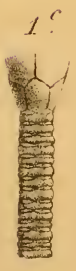
11.

10.

1 b.

12.

13.


1 c.

1 e.

PLATE X.

HETEROCRINUS TENUIS (page 50).

Figure 1*a*. *Heterocrinus tenuis*, from the Trenton limestone, near the City of Montreal.

" 1*b*. Part of column and base of another specimen on same slab.

" 1*c*. Enlargement of 1*b*.

" 1*d*, 1*e*. Other fragments on the same slab of stone.

[See also Plate IV.]

CARABOCRINUS TUBERCULATUS (page 33).

Figure 2*a*. The only specimen collected.

" 2*b*. Three joints of the column, enlarged.

" 2*c*. One of the joints of the arms, enlarged.

SYRINGOCRINUS PARADOXICUS (page 65).

Figure 14. A specimen collected at Beauport.

COLUMNS OF UNDETERMINED GENUS.

Figure 3. A quinquepartite column from the Trenton limestone, City of Ottawa.

" 4–7. Fragments from Hudson River group, Point William, Lake Huron.

" 8. From Trenton limestone, Montreal.

" 9. The same, enlarged.

" 10. From the Hudson River group, Anticosti.

" 11. The same, enlarged.

" 12. A small striated column from the Trenton limestone, City of Montreal.

" 13. The same, enlarged.

FIGURES AND DESCRIPTIONS OF CANADIAN ORGANIC REMAINS.

DECADE I.--FOSSILS from the base of the Trenton Group. By J. W. SALTER, Palæontologist of the Geological Survey of the United Kingdom.

" II.—GRAPTOLITIDEÆ from the Lower Silurian. By Professor JAMES HALL, Palæontologist of the State of New York.

" III.—CYSTIDEÆ and ASTERIDEÆ. By E. BILLINGS. Genus CYCLOCYSTOIDES. By E. BILLINGS and J. W. SALTER. Palæozoic Bivalve ENTOMOSTRACA. By T. R. JONES, Esq., F.G.S.

" IV.—CRINOIDEÆ from the Lower Silurian. By E. BILLINGS.

Decades I., III. and IV. are published. Decade II. will be published in about six months.

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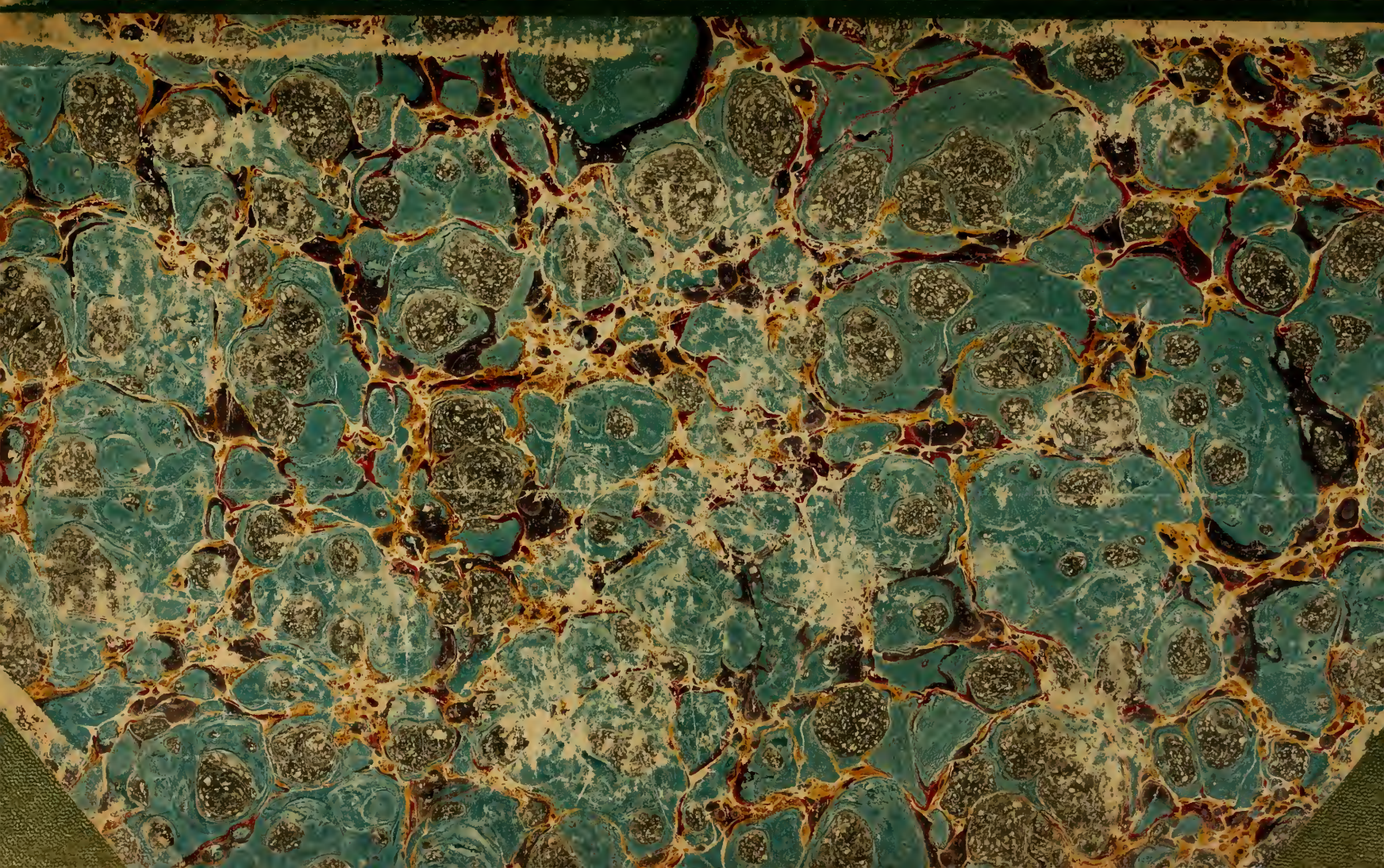
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